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Report of the
TWENTY-NINTH SOUTHERN PASTURE AND FORAGE CROP
IMPROVEMENT CONFERENCE

Clemson University
Clemson, South Carolina 29631

May 16-18, 1972

AND

Contributed Papers of Work Groups Meeting
in Conjunction with SPFCIC
May 16, 1972

Southern Forage Breeders' Group
Southern Forage Physiology and Ecology Work Group
Southern Forage Extension Work Group

UNITED STATES DEPARTMENT OF AGRICULTURE
Agricultural Research Service
Plant Science Research Division

TABLE OF CONTENTS

	<u>Page</u>
SOUTHERN PASTURE AND FORAGE CROP IMPROVEMENT CONFERENCE, May 17, 1972	
Introduction	1
FORAGES AND LIVESTOCK IN SOUTH CAROLINA	
Resources for South Carolina Agriculture -- James E. Halpin	2
The Demand for Forage Crops in South Carolina -- W. I. Golden	4
Forage Systems -- Luther P. Anderson	5
Recent Developments and Pressing Needs in Dairying -- W. A. King ...	8
Recent Developments and Pressing Needs in Beef Production -- R. F. Wheeler	12
SYMPOSIUM: WARM SEASON, PERENNIAL GRASSES: TOWARD BETTER SYSTEMS OF UTILIZATION	
The Differences in Physiology and Anatomy of Temperate and Tropical Grasses -- R. Harold Brown	15
Grazing Trials on the Flatwoods of South-Central Florida -- E. M. Hodges	25
Agronomic and Nutritional Aspects of Producing Coastal Bermudagrass Pellets -- W. A. Balk	27
Overseeding for 365-Day Grazing -- J. N. Pratt	41
Status and Outlook of Forage Harvesting Systems -- James B. Stere, Marketing Research Department, New Holland Division, Sperry Rand Corporation (Paper not received).	
The American Forage and Grassland Council and You -- Warren C. Thompson	56
Fueling the Forage Revolution in the South -- Del Deterling	59

Committee Reports:

	<u>Page</u>
Pre-Conference Executive Committee Meeting	65
SPFCIC General Business Meeting	66
Report of Forage Evaluation Committee	66
Report of Resolutions Committee	67
Post-Conference Executive Committee Meeting	68
SOUTHERN FORAGE BREEDERS WORK GROUP, May 16, 1972	70
Potential for Development of High Quality, Winterhardy Bermudagrass Varieties -- Glenn W. Burton	70
Breeding Improved Varieties of Grasses Belonging to the genus <u>Panicum</u> -- Ethan C. Holt	71
Status and Potential of Orchardgrass Improvement -- Lincoln Taylor..	74
Problems and Progress in Breeding White Clover -- Pryce B. Gibson ..	76
Alfalfa in the Southern States -- Thad H. Busbice	80
Barriers to Improving Forage Digestibility -- Warren Monson and Wayne W. Hanna	94
Panel Discussion - "The Case for Annual Legumes in the Southeast" -- R. C. Leffel, Moderator	
Use of Legume Forages in Ruminant Diets -- Phillip R. Utley	100
The Case for Annual Legumes in the Southeast -- Carl S. Hoveland ..	102
The Place for Annual Legumes in the Southeast - an Economist's Viewpoint -- James G. Dillard	105
SOUTHERN FORAGE PHYSIOLOGY AND ECOLOGY WORK GROUP, May 16, 1972	118
Converting Brush to Tall Fescue --W. Elmo Baumann, W. E. McMurphy and L. M. Rommann	118
Status of Tall Fescue Research in Arkansas -- A. E. Spooner	120
Fescuegrass in Louisiana -- C. L. Mondart, Jr.....	121
Tall Fescue Research in Mississippi -- V. H. Watson, C. Y. Ward, M. C. Futrell, D. R. Farnell, and W. E. Poe	122

	<u>Page</u>
Tall Fescue Research in Alabama -- C. S. Hoveland	123
Status of Tall Fescue in Florida -- James T. Johnson	124
Research in Georgia on Fescue -- R. H. Brown	126
Status of Tall Fescue Research in South Carolina -- M. W. Jutras	127
Effect of Timing of N Application on Growth of Tall Fescue in Piedmont North Carolina -- W. W. Woodhouse, Jr.	128
Evaluation of Tall Fescue Alone and in Mixture with Ladino Clover or Grazed in a System with Coastal Bermudagrass -- J. C. Burns and Lemuel Goode	130
Changes in Quality and Chemical Constituents of Tall Fescue through- out the Growing Season at Various Degrees of Defoliation -- J. C. Burns and Douglas S. Chamblee	132
Status of Tall Fescue Research in Kentucky -- T. H. Taylor and W. C. Templeton	134
Research on Tall Fescue in Tennessee -- John H. Reynolds	135
A Short History of Kentucky 31 Fescue -- E. N. Fergus	136
Forage Management and Utilization in Relation to Climate (increasing rainfall and temperature) -- C. M. Campbell and A. S. Whitney.	140
The Volatile Alkaloids of Tall Fescue Seed and Forage (<u>Festuca arundinacea</u> Schreb.): Isolation, Identification and Effect on Weight Gains of Rats -- J. D. Robbins, S. R. Wilkinson and D. Burdick	152
SOUTHERN FORAGE EXTENSION WORK GROUP, May 16, 1972	163
<u>South Carolina Forage Programs</u>	
Forage Situation in South Carolina -- L. R. Allen	163
Fertilization for Nutrient Balance in Forages -- C. L. Parks	164
Closed-Circuit Educational T.V. Programs on Beef Production and Management -- J. N. Williams II	164
Computers in Dairy Cattle Nutrition -- W. L. Northern	167

Selling a Forage Educational Program -- N. D. Morgan	<u>Page</u> 168
Industry Sponsored Pasture Demonstrations -- W. E. Monroe	171
Handling Forage from the Field to Storage -- Wendell Bowers	174

Forum - Research by Extension, What, Why, How, Benefits, Disadvantages -
S. H. Dobson, North Carolina, Moderator

Research by Extension -- L. R. Allen	189
Research by Extension - What, How, Why, Benefits and Disadvantages -- E. Lamar Kimbrough	191
Summary of Survey of States -- S. H. Dobson	191

Registration List --1972	192
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Reported by R. C. Leffel, Permanent Secretary,
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TWENTY-NINTH

SOUTHERN PASTURE AND FORAGE CROP IMPROVEMENT CONFERENCE
May 17-18, 1972 - Clemson, S.C.

Robert C. Buckner, Chairman

INTRODUCTION

Opening Session:

The twenty-ninth meeting of the Southern Pasture and Forage Crop Improvement Conference was opened by Conference Chairman, R. C. Buckner. Chairman Buckner introduced all present by States, countries, and industries represented. Director O. B. Garrison extended a welcome to Clemson to all in attendance. He commented on the many changes at Clemson during the last 14 years, since the last meeting of SPFCIC at Clemson in 1958, and on a current upswing in agricultural interests in South Carolina. The Host Institution's presentation of "Forages and Livestock in South Carolina" was chaired by L. P. Anderson. Anderson announced that transportation was available for the tour Thursday morning to the Simpson Experiment Farm, beginning at 8:30 A.M., and that the banquet will be held in the Golden Room of the Clemson House, beginning at 7:00 P.M.

Resources for South Carolina Agriculture
James E. Halpin
Clemson University

South Carolina is not a large state, but it is a very diverse one. The land area is about 1% that of the 48 contiguous states, about 4% of the land area east of the Mississippi River. At the same time, its population, at approximately 2.6 million, is not very high. It represents approximately 1.3% of the population of the 48 contiguous states, about 2% of the population east of the Mississippi.

South Carolina is really under-populated. In 1970, the number of people per square mile in the United States (48 states) averaged 68: South Carolina averaged 86, while the United States east of the Mississippi River averaged 151. If we take the 46 counties in South Carolina and examine the population per square mile, we find that only 4 counties exceed the 151 figure (consequently, are more populated than the United States' average east of the Mississippi River) while 28 counties have fewer people per square mile than the average of the 48 contiguous states. The four counties with higher population densities encompass the cities of Spartanburg and Greenville areas of the Piedmont, Columbia in the Sandhills, and Charleston on the coast. These three population areas are located in three diverse regions of the state, and literally cover the state from the mountains to the sea.

The diversities of South Carolina's soils provide a great range of environments for agriculture. This means a variety of environments for livestock and pastures as well.

The coastal plain is divided into two regions, upper and lower, and represents our major agricultural belt. Above the coastal plain are the sandhills which literally cut across the center of the state from the northeast to the southwest. Geologically, this region represents the old shoreline of the prehistoric Atlantic Ocean. Between the sandhills and the mountains is another major belt called the Piedmont, characteristically one with clay soils. And the mountain region caps off the Piedmont on our borders with Georgia and North Carolina in the northwestern portion of the state. The changes in altitude from the coastal plain, at sea level to the mountains rising in the northwestern corner of the state represent diverse changes in climate as well. Hence, climatic changes and differences in the soils in these areas result in a small state having the capacity to produce a wide variety of crops which can support a variety of industries and related agricultural enterprises as well.

All of South Carolina receives adequate rainfall and this rainfall is well distributed throughout the year. We are particularly blessed with generally well defined seasons. Frost free periods vary, being somewhat shorter in the mountains up to over 10 months on the coast.

As one looks at the top 12 agricultural commodities in the state, representing collectively 95% of our total agriculture, we find that six of these are related to animal production. Beef cattle rank fourth in South Carolina with a value

in excess of \$40,000,000 per year, approximately 9% of our total agriculture. The production of dairy products ranks 5th at \$35,000,000 per year, approximately 8% of our agricultural income. Swine are 6th at \$30,000,000 per year at 7%. Poultry for eggs, turkeys, and broilers, complete our animal commodity picture. Both our beef cattle and dairy cattle are generally placed on pastures as the production of beef cattle in feed lots has not become well established in the state as yet. Hence, the interests and efforts of pasture specialists are of obvious interest to all of us.

South Carolina has an excellent interstate highway system backed up by fine state and county secondary roads as well. Four interstates cut across the state. A great majority of the interstate mileage has already been constructed. Actually, I do not know where one can find a state road in this state which is not paved. Our fine highways make it possible for farmers to get their agricultural products to the market place rapidly and easily.

From these comments we have seen that the various regions of South Carolina have a great diversity in soils, excellent climates, and fine roads. Couple these with great people and you realize why agriculture in South Carolina is moving forward today.

Thank you.

The Demand for Forage Crops in South Carolina

W. I. Golden

State Leader, Extension Agricultural Programs, Clemson Univ.

South Carolina, as most States, is experiencing an increase in per capita income which is highly related to the consumption of red meats.

Per capita consumption of beef in South Carolina in 1950 was around 55 pounds; in 1971, per capita consumption was estimated to be 98 pounds. In an effort to meet the increasing demand for beef and to take full advantage of the climate and soil condition for producing forage, South Carolina farmers (full and part time) have increased the pounds of cattle and calves produced from 122 million pounds in 1960 to 190 million pounds in 1971. The number of cattle and calves has been growing by leaps and bounds during the past 10 years. (687,000 head January 1, 1972)

To support the increasing beef numbers in the State, the dairy industry, and the pellets demand by the poultry industry, the demand for forage crops has increased.

This demand will continue to increase as the demand for meats increases and the livestock and poultry industry is expanded. However, this demand will put pressure on plant breeders and others to do a better job of producing forage crops that have higher yields per acre in terms of net energy.

At the present time we have over 2 million acres in pasture of some kind, produce about 80,000 acres of hay and grow about 50,000 acres of silage. These crops provide well over 2 acres of forage per animal in the State at the present time. The point I would like to make is that as urbanization takes place and land is taxed at a higher rate, livestock producers cannot afford 2+ acres per animal. This means that agricultural scientists must develop better forage crops as well as cultural practices if the demand for forages is going to be met in the future.

In closing, let me state again that the livestock and poultry industry in South Carolina is expanding at a steady rate and will continue to do so long as population and/or per capita income increases which will continue to bring pressure to bear on the demand for economically produced forage crops that are high in net energy. The demand for land for urbanization and as well as farm use will continue to increase the value of land; thus agricultural scientists must meet the demand to increase the quality and quantity of forage produced on an acre.

FACTS

- 1971 - 28,189,000 broilers produced in S.C. They use pelleted Coastal bermudagrass. This industry will continue to expand.
- 1971 - 18,000 cattle on feed - 1972 - 23,000. Ten years ago we had no cattle feeding industry. This industry will continue to grow and demand more silage and pasture for conditioning.
- 1972 - 65-66,000 dairy cattle being milked. 18-19,000 replacement heifers. Stable or decreasing but the demand for high quality forage to replace purchased feed is a real demand.
- 1972 - 600-610,000 beef cattle and calves. This number will continue to increase.

1969 - Acres of pasture:

Cropland used for pasture	700,000
Temporary pasture	300,000
Woodland pasture	800,000
Other pasture	<u>200,000</u>
	2,000,000 acres

1971 - Acres of silage

corn	21,000 acres (low due to blight)
sorghum	<u>24,000</u>
total	45,000

1971 - Acres of hay - 80,000

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Forage Systems - South Carolina

Luther P. Anderson
Clemson University

South Carolina is a fairly typical Atlantic Coast State with an average annual rainfall of 40-45 inches. The growing season is long but there are periods of the year when every forage dependent enterprise requires careful management if problems are to be avoided. Of course, the variability of our soils, our climate and our farmers are real challenges in the way of progress. These are general situations and we must base our overall recommendations on them.

Wouldn't it be easy if we could establish a forage system that would furnish abundant nutritious grazing for 12 months throughout the four seasons. This will be accomplished through the efforts of this group and the support of our

clientele.

We have in South Carolina approximately one million acres of improved pasture. Summer grazing is the least of our problems since we have acceptable warm season species. Cool season species are lacking and especially for the lighter textured Coastal Plain soils and herein lies our most urgent need in the State.

The use of annual grazing, silage, green chop and double cropping are several of the choices available to the dairymen or cattlemen; however, harvesting, handling and transporting requires labor and equipment. Two expensive items in the budget. Profit margins have been narrow in the past and most cattlemen have chosen the lowest management system available. The perennial grasses have been the foundation for our grassland farming.

Common bermudagrass has long been used and still fills the need for a low maintenance warm season perennial. Pensacola bahia is used throughout the Coastal Plain and has been established in some areas of the Piedmont. Coastal bermuda is used extensively throughout the area of well drained soils of the State and has given us our greatest boost in the area of intensive management.

Cool season perennials have been limited to tall fescue and this to the Piedmont and somewhat poorly drained soil in the lower Coastal Plain. Orchardgrass stands have been held for two to three years on some sites and in the cooler highlands much longer, but in general it has not filled the need for a more palatable cool season perennial.

We recognize the importance of legumes in our forage systems and are striving to increase them in our pastures. Tillman clover, developed here at Clemson, has proven to be an asset to our forage quality improvement effort. Serala lespedeza has met with approval in the dry areas of our State.

We are still attempting to get back into the alfalfa picture and we have just learned of a new systemic insecticide that has been cleared for use in this crop.

Annual forage crops are no different here than in other States; however, we hope with higher priced cattle and new methods of seeding, harvesting, and storing that the acreage will increase. The Coastal Plain must depend on winter annual grazing since there is no acceptable cool season perennial for that area. Silage, an accepted and highly desirable dairy forage, is being carefully studied for the beef production area.

These forage species are not new and most of the ones available have been bred for yield. Yields are within reach but the maintenance of high quality escapes us. Hay is definitely a high risk crop and we must improve our methods of harvesting and storing or seek some other method of saving forages for utilization.

The system of forage production for a cow-calf operation in the Piedmont

area is to utilize as much as possible perennial summer and winter grasses. Usually an attempt will be made to get clover in the cool season pastures and with proper management quantity and quality can be improved. Low stocking rates, one cow and calf on two acres, have allowed a low level of management. This luxury we can no longer afford and stocking rates are now being increased along with fertilization rates and the use of high yielding grasses such as Coastal bermuda.

Generally a larger acreage of winter grass than summer grass will be maintained. We would like to see a third area planted to a mixture of clover and fescue and grazed when needed (summer or winter). Some of these ideas will be shown to you on our tour Thursday morning.

In the Coastal Plain, Coastal bermuda and bahia are utilized for summer grazing. If hay is to be harvested, Coastal is fertilized a little more and cuttings are made. Annual winter grazing is used in many areas and growers are over-seeding soybean fields with rye for early grazing. This practice is also being used to carry a calf over to a heavier weight. Research in the area of sod-seeding to furnish late fall and early spring grazing is being carried out and the interest is high.

For utilizing all available land areas, many cattlemen are interested in growing silage crops and this may assist us in increasing our livestock potential in the Coastal Plain. The dairymen are setting the pace and paving the way for evaluating silage production in all areas.

In summary:

1. We need a cool season perennial for the light textured Coastal Plain soils.
2. We need an aggressive move to get more legumes into our perennial grasses.
3. We need more palatability and digestibility in our forages.
4. We need support for forage research from the people that utilize forages.
5. We need a new look at harvesting and storage of forages.
6. We need to investigate the potential of an acre of land when utilized to the fullest.
7. The luxury of low management levels can no longer be enjoyed.

The systems we use in this State could be improved - hopefully this conference will assist us in carrying out our program in Research and Extension to achieve this goal.

RECENT DEVELOPMENTS AND PRESSING NEEDS IN DAIRYING

W. A. King
Clemson University

Dairy cattle feeding, management and breeding programs constantly change. Factors that affect management including labor, capital, and income have influenced feeding practices more than most researchers, educators, and dairymen realize.

Since 1950 the average size DHIA herd in the United States has increased from 25 to 65 and in South Carolina from 43 to 108 cows. Commercial dairy farms in the United States

Size of Herds on DHIA		
	U. S.	S. C.
1950	25	43
1960	36	61
1970	65	108

have decreased from 602,000 to approximately 300,000 and the number of milking cows has dropped from 25 million to 12.4 million.

Number of Cows on DHIA Production				
U. S.			S. C.	
	No. of cows	Milk production	No. of cows	Milk production
	mil.	lb.		lb.
1950	25.0	9,172	158,000	6294
1960	17.5	10,561	109,000	8567
1970	12.4	12,750	66,000	11,384

The average DHIA production per cow (9,172 pounds in 1950) has increased more than 3,500 lb. in the nation and over 5,000 lb. in South Carolina. Total milk production has decreased from the high of 127 billion pounds to approximately 117 billion pounds in 1970. Production is now much more in line with consumption.

Factors including labor scarcity, equipment costs and high money cost necessitate more and higher producing cows on each farm and more milk produced per worker. Ten years ago each worker averaged 100,000 to 200,000 pounds of milk annually. Today, a worker may produce 400,000 pounds or more annually.

South Carolina's DHIA annual summaries show the general trends of feeding cows. Many dairymen have changed from pasture to silage. In 1969, 86 percent of South Carolina's dairymen fed corn silage and eight percent fed sorghum silage.

Percent of Nutrients by Sources for South Carolina Cows on DHIA			
	1950	1960	1970
Pasture	43	27	18
Hay	10	11	9
Silage	7	22	28
Concentrates	40	40	45
Income/feed cost	\$ 236	\$ 283	\$ 496

Why have dairymen lost interest in pasture? After all, isn't pasture the most natural, nutritious feed? Dairymen find many factors are involved. Contemplate obtaining good grazing daily for 300 cows compared to 40 cows. While dairy farmers may grow sufficient grazing for 3 to 10 cows per acre, they must consider the forage lost under the heavy stocking rates.

Pasture is never the same from day to day. It is either improving or decreasing in nutritive value. Productive value becomes most difficult to control due to weather. Pasture, as a major source of nutrients for a high producing herd, therefore, is seldom seen with large herds.

Many dairymen use permanent pastures for dry cows and heifers. They use temporary pastures for milking cows primarily as supplemental feed. Two or three hours grazing per day, particularly in the fall on temporary pastures, has great value in a southern milking herd.

Several southern states conduct forage testing programs. The South Carolina program represents more or less typical results. With silages 97 percent of the samples were excellent or good, whereas only 18 percent of the hays were in the same classes.

Summary of South Carolina Forage Testing (1962-70)			
	Hay	Corn silage	All silages
	%	%	%
Excellent	5	90	79
Good	13	9	18
Fair	38	1	2
Poor	44	0	1

Yield per acre in 1968 for all hays averaged 1.56 tons. Coastal bermudagrass hay averaged 2.75 tons per acre. Forage quality must be considered along with the yield. Weather is a tremendous, uncontrollable factor in making quality field cured hay. Thus, when dairymen add up their hay problems including weather, crop variety (grass in the South vs. legumes), they conclude that hay is losing out in the South for feeding milking cows.

Dairymen ask themselves why should a farm maintain expensive equipment for both hay and silage?

Silage is the forage for now and in the future. With corn silage, herd managers preserve and feed 50 percent more nutrients per acre than when harvesting the corn for grain. The annual consumption of silage reported in 1950 was 2,261 pounds per cows on DHIA in South Carolina. In 1970 the average exceeded 13,700 pounds. Each dairy farm should ensile annually 12 tons per cow, almost double the current amount.

Although many factors are important, lactation depends first on reproduction and then the most important factor during lactation is feed consumption. High rates of forage intake can be obtained on a silage program.

Silage offers palatability, succulence and high energy to the cow and opportunities for full mechanization in feeding, relatively low storage cost and ensiling as a reasonably easy method to control weather, maturity and harvesting problems.

Dairymen must accept the fact that their cows have been underfed energy-wise for years. Higher producing herds are a must for economical milk production, and the grain portions of the rations must supply the nutrients not supplied by the forage.

The amount of grain needed depends, in part, upon the amount and quality of the forage offered the cows. Generally, it is considered that forage intake contributes 70 percent and digestibility contributes 30 percent to the forage nutrients available to the cows.

The grain portion of the cows' rations has increased percentage wise in South Carolina from 40 percent in 1950 to 45 percent in 1970. This trend is apparent throughout the nation and accounts, in a great measure, for today's increased production per cow.

Further increases in production feed-wise, should come from much greater use of high-quality forages, especially silages.

Can herdsmen feed silage as the only forage? Researchers find the answer is definitely yes. Today such a program is not rare. Some milking herds have been fed this way for five or more years.

The future of feeding cows will be in the all-in-one silage program. The grain is mixed either at ensiling or as the silage is fed, more often the latter. This will be a balanced-ration, with the herd divided into several groups according to production level. Varying grain levels will be fed according to production. All this will be mechanized. The silage will be analyzed periodically and the rations computer calculated.

The change is not and will not be easy. The cows must be adjusted to the rations and management facilities must be rearranged. Some people believe hay or pasture must continue to be part of the feeding program. It is well to maintain the dry cows on either pasture and/or hay. Cows need to get off concrete, and other forages at this time would be in order, nutritionally as well as from the management standpoint.

Corn silage as the sole forage is an unexcelled high-energy forage. The ear contributes a high percent of the energy content. Excellent corn silage TDN content runs from 65 to 70

percent on the dry basis. On the other hand, corn silage is low in protein, calcium and phosphorus and may be low in magnesium, sulfur and iodine. Good-quality corn silage, ensiled in the dent stage with about 30 percent dry matter content, should supply all the vitamin A and D required by the cow.

Protein concentrates such as cottonseed or soybean meal contribute mainly protein but are also good sources of phosphorus. The trend today is to add 10 pounds of urea to corn as it is being ensiled. The urea substitutes for some of the protein needed but also reduces the phosphorus supply. Corn silage is low in calcium. Therefore, to balance the ration 2% calcium phosphate, 1% trace mineralized salt, and perhaps magnesium oxide, if needed, should be mixed in the concentrate. Not enough is known about sulfur to make a recommendation at this time.

The dairy industry must make plans for the future. The feeding of grains is in competition with feeding humans. Thus, forage (silage) feeding must be the backbone of the dairy program. Urea, substituting for protein, will be used more and more as research solves problems in its maximum use which may be to replace all oil meals.

Corn, although the best all-around, need not be the only crop used for silage. There are a number of good forage sorghums with high seed content that yield well on upland soils. Grain-type sorghums are excellent but the yield per acre is generally low. With both types of sorghums good consumption and milk production are obtained. Grass silage has a particular place in feeding dairy herds as it affords double use of silos and often fits better into the farm crop system. Each dairyman must select the crops, and system which best suits his farm.

Economical milk production of today and the future depends to a great extent on the growing, harvesting and feeding of ample quantities of high quality forages. The forage must be palatable and available to the cow when she wishes to eat.

Time is a factor in the feeding of high producing herds. What's time to a cow? The rate of feed consumption by a cow averages: concentrates - 0.5 pounds per minute, hay - 0.1 pounds per minute and silage - 0.3 pounds per minute.

By allowing two hours for milking, watering, etc., six hours for resting, eight hours for ruminating and eight hours per day for eating a 1,300 pound cow producing 80 pounds of milk and fed 110 pounds of silage and 32 pounds of concentrate would need more than seven hours to consume her feed. This doesn't leave much eating time for cows producing more than 80 pounds of milk per day. High producing cows find themselves pushed for time to consume the necessary feed.

R. F. Wheeler

Clemson University

Due to the deficiency of grain in South Carolina and the Southeast in general, research with beef cattle at Clemson University has been concerned with the maximum utilization of both summer and winter forages for maintaining the cow herd and fattening steers.

Research at the Edisto Experiment Station, Blackville, South Carolina, indicates that steers can be finished to the good slaughter grade when fed 1% of the body weight of corn while the animals are grazing Coastal bermuda forage. There was no economical benefit from adding protein supplement to the ration; therefore, it seemed that the cattle were getting adequate protein from the forage plus corn fed at the rate of 1% of the body weight.

Italian ryegrass-Clemson clover mixture has been used successfully at Clemson for wintering the beef cow herd as well as fattening steers. Other studies have involved fattening steers using fescue as the winter forage. When fescue was used as the forage with 1% of the body weight of grain, a protein supplement was needed for maximum performance.

There is an interest in greater utilization of corn silage for fattening steers in drylot, and we have done considerable work along this line at this Station. The present plans are to implement a project at the Edisto Experiment Station, Blackville, South Carolina, fattening steers using both corn silage and sorghum silage.

When forages are used to the maximum extent for fattening cattle, and this will vary somewhat depending on the forages concerned, the fat will tend to be slightly yellow and also will tend to be slightly softer than fat coming from cattle finished in drylot.

As a cooperative project with the Agronomy Department, we are currently conducting research feeding prolix, a liquid supplement, to cattle while grazing different forages. This is a cow-calf operation, and it will be several years before we have a great deal of information.

Fescue seems to fit in very well as a forage for wintering beef cows in the Piedmont; however, fescue does not grow very well on most soils down state. There is a need for a perennial winter forage that will grow on our light sandy soils. There is a need for better utilization of Coastal bermuda pastures. It is now the 17th day of May, and the Coastal is just beginning to grow due to our dry weather up until a few days ago and also due to the cool nights. There is a need to establish another grass and/or legume in the Coastal or possibly topseed Coastal in order to get more grazing days from Coastal bermuda pastures.

BEEF *

% PRODUCTION WAS OF CONSUMPTION

<u>State</u>	<u>Year 1950</u>	<u>Year 1960</u>	<u>Year 1970</u>	<u>Year 1971</u>
South Carolina	27.2	36.2	37.6	41.63
North Carolina	27.5	32.4	27.5	28.89
Georgia	53.4	61.7	65.0	69.13

* This material was prepared by Dennis E. Crawford, Associate Agricultural Economist, Department of Agricultural Economics and Rural Sociology, Clemson University, Clemson, South Carolina.

The Differences in Physiology and Anatomy of Temperate and Tropical Grasses

R. Harold Brown
University of Georgia

The realization that differences existed between temperate and tropical grasses is, of course, not new. In recent years, however, new observations have been made and older data brought together which present a striking contrast between the group of grasses which grow in temperate regions and those of tropical origin. For convenience those grasses which grow best at high temperatures (approximately 30 C) will be referred to as tropical and those which grow better at lower temperatures will be called temperate.

Water Use Efficiency

Shantz and Piemeisel (1927) published data which, indicated that tropical grasses required less water to produce a gram of dry matter than did temperate grasses. Although the data were not interpreted in this way originally, it can be seen from table 1 that those species classed as tropical used less water per unit of dry matter produced than did temperate grasses. These data indicate that the tropical grasses either produced more dry matter or used less water than temperate ones. It is not clear whether temperate grasses transpire faster than tropical ones, although there are indications that they do (Downes, 1969). There are sufficient data, however, to conclude that tropical grasses have higher dry matter production rates (Cooper, 1970).

Photosynthesis

Higher productive capacity in tropical grasses reflects higher photosynthetic potential. In 1963, Hesketh and Moss² found that corn and sugarcane absorbed CO₂ at much higher rates (60mg/dm²/hr or more) than did temperate grasses (30mg/dm²/hr or less). Similar observations were made by Murata and Iyama (1963) who found that bermudagrass and bahiagrass had higher photosynthetic capacities than several temperate species. The higher photosynthetic capacity in tropical grasses has been demonstrated many times in recent years.

In addition to the higher photosynthetic potential in tropical grasses, it has been found that higher light intensities are required to obtain maximum CO₂ uptake. In tropical species photosynthesis increases as light intensity increases up to near full sunlight (10,000 to 12,000 foot candles) (Hesketh, 1963; Hesketh and Moss, 1963). On the other hand photosynthesis in temperate grasses is maximum at about 3,000 to 4,000 foot candles.

Optimum temperature for photosynthesis in tropical grasses is in the range of 30-35 C, whereas the optimum temperature for temperate grasses is 15 to 25C. This might be expected from the adaptation of these species to cool or warm season conditions. The higher light saturation intensities and higher optimum temperatures for photosynthesis in tropical grasses means that they are capable of exploiting summer conditions more fully than can temperate

Table 1. - Acreage and production of corn for grain for North Carolina, South Carolina, and Georgia, Years 1950, 1960, 1970, and 1971

	Acreage harvested acres	Total production bushels
<u>North Carolina</u>		
1950	2,248,000	74,184,000
1960	1,938,000	96,900,000
1970	1,400,000	70,000,000
1971	1,520,000	86,640,000
<u>South Carolina</u>		
1950	1,446,000	26,320,000
1960	842,000	28,207,000
1970	402,000	10,854,000
1971	454,000	24,516,000
<u>Georgia</u>		
1950	3,259,000	49,536,000
1960	2,644,000	84,608,000
1970	1,426,000	44,206,000
1971	1,532,000	85,792,000

Source: Agricultural Statistics, 1951, 1961, and 1971.

Table 2. - Total population for North Carolina, South Carolina, and Georgia, Years 1950, 1960, and 1970

	Total population
<u>North Carolina</u>	
January 1, 1950	4,076,000
January 1, 1960	4,577,000
January 1, 1970	5,082,059
January 1, 1971	5,160,323
<u>South Carolina</u>	
January 1, 1950	2,116,000
January 1, 1960	2,395,000
January 1, 1970	2,590,516
January 1, 1971	2,613,123
<u>Georgia</u>	
January 1, 1950	3,443,000
January 1, 1960	3,959,000
January 1, 1970	4,589,000
January 1, 1971	4,664,728

Source: U. S. Department of Commerce, Bureau of the Census.

ones. These characteristics also imply that tropical grasses are very competitive under summer conditions, but much less so in other seasons. This has, of course, been observed by most agronomists and others working with mixtures of temperate and tropical grasses.

Photorespiration

Much research has been and is being conducted to explain the higher photosynthetic capacities of tropical grasses. Some of the differences observed between the two groups of grasses relate to photorespiration. It is easy to demonstrate a loss of CO_2 from leaves of temperate grasses in the light. This may be done by passing CO_2 -free air through a leaf chamber and measuring the CO_2 in the chamber exhaust. Alternatively it may be measured by feeding the leaf $^{14}\text{CO}_2$ in the light and monitoring $^{14}\text{CO}_2$ evolved from the leaf after flushing residual $^{14}\text{CO}_2$ from the leaf chamber. When leaves of tropical grasses are subjected to either of the above conditions little or no CO_2 can be detected coming out of the leaf. Higher photosynthetic rates in tropical grasses have been partially attributed to the absence of photorespiration.

The CO_2 compensation concentration is a characteristic closely related to photorespiration and has been shown to differ significantly between temperate and tropical grasses. The CO_2 compensation concentration reflects the ability of plants to remove CO_2 from an atmosphere depleted in CO_2 . If tropical grasses are enclosed in an air tight compartment at high light intensities, they are able to remove essentially all of the CO_2 (5 to 10 parts per million may remain; 300 ppm is normal air concentration) (Table 2). Temperate grasses can reduce the CO_2 to about 30 to 50 ppm under similar conditions. The difference in CO_2 compensation concentration (0-10 versus 30-50 ppm) indicates that tropical grasses have a higher capacity to extract CO_2 from the air.

A second characteristic related to photorespiration is the inhibition of photosynthesis by oxygen (O_2) in temperate grasses. When O_2 in the atmosphere is reduced from 21% to near zero photosynthesis is increased by 40-50% in temperate species, but is hardly affected in tropical grasses (Table 3). One explanation of this phenomenon is that photorespiration is stimulated by high O_2 levels and therefore net photosynthesis is reduced. The fact that tropical grasses are not affected by O_2 may be taken as evidence that they have little or no photorespiration.

Carbon Dioxide Fixation Pathway

For several years it was assumed that CO_2 fixation in chloroplasts of leaves followed the biochemical pathway described by Calvin and his co-workers (1957). The first product of CO_2 incorporation in the Calvin cycle is 3-phosphoglyceric acid. Ribulose-1-5-diphosphate (RuDP) is combined with CO_2 to produce a 6-carbon intermediate which is then cleaved to produce two molecules of 3-phosphoglyceric acid. Kortschak et al. (1965) found, however, that upon supplying $^{14}\text{CO}_2$ to sugarcane leaves the ^{14}C was

incorporated first into the 4-carbon dicarboxylic acids, malic and aspartic. Hatch and Slack (1966) and Hatch et al. (1967) extended the research with sugarcane and describe a pathway of CO_2 fixation which is found predominantly in tropical grasses and is called the "Hatch-Slack cycle" or " C_4 cycle".

In the C_4 cycle phosphoenolpyruvate (PEP) is combined with CO_2 to form oxaloacetate, which is rapidly converted to malate and aspartate. The enzyme responsible for CO_2 fixation is PEP carboxylase. This enzyme in the C_4 cycle is analogous to RUDP carboxylase in the Calvin cycle.

Table 4 illustrates the levels of PEP carboxylase and RUDP carboxylase found in temperate and tropical grasses. PEP carboxylase activity is much higher than RUDP carboxylase activity in tropical grasses and the reverse is true in temperate species. The level of RUDP carboxylase in tropical grasses is rather high, indicating appreciable Calvin cycle activity in these species. This will be discussed further in the next section.

Anatomy

Leaves of tropical grasses possess a well developed layer of cells surrounding the vascular bundles. This layer of cells is usually referred to as the vascular bundle sheath. Cells in the bundle sheath usually have large amounts of chloroplasts, mitochondria and other organelles. In some species the chloroplasts in the bundle sheath lack well developed grana. Chloroplasts in bundle sheath of most tropical grasses store large amounts of starch. Radiating out from the vascular bundle sheath are mesophyll cells which may be loosely arranged, and which are characterized by much larger vacuoles and fewer chloroplasts than occur in the bundle sheath cells. In contrast temperate grasses usually have poorly developed bundle sheaths and very few chloroplasts in the bundle sheath cells.

The special characteristics of leaf anatomy in tropical grasses appear to be important in their photosynthetic processes. Products of photosynthesis appear in the bundle sheath so rapidly that it was thought at one time that the bundle sheath was the site of photosynthesis. Dr. C. C. Black and his co-workers (Edwards et al., 1970; Edwards and Black, 1971) have separated bundle sheath and mesophyll cells and have characterized some of their photosynthetic properties. Table 5 shows enzyme activities in crabgrass which indicate that the Calvin cycle operates in the bundle sheath cells and the C_4 cycle in the mesophyll. It appears from this and other research that CO_2 is fixed in the mesophyll cells of tropical grasses by the C_4 cycle. One or more of the 4-carbon dicarboxylic acids is then transported to the bundle sheath cells where it is decarboxylated producing a 3-carbon unit and CO_2 . The resulting CO_2 is then fixed by the Calvin cycle and the 3-carbon compound is returned to the mesophyll cells to complete the cycle. There is speculation and some data to support the hypothesis that the C_4 cycle in the mesophyll has a higher potential for fixing CO_2 than does the Calvin cycle and that the C_4 cycle, therefore, concentrates CO_2 in the bundle sheath cells as the 4-carbon acids are decarboxylated there. This high CO_2 concentration in the bundle sheath results in higher rates of

photosynthesis by the Calvin cycle and consequently by the whole leaf.

Digestion

The differences in anatomy of tropical and temperate grasses indicate that there might be some differences in the rate at which these plants are digested by animals. Tropical grasses are usually thought to be of low quality, but few studies of digestibility have been done in which temperate and tropical grasses have been fed in the same experiment. Minson and McLeod (1970) indicated that differences in digestibility of temperate and tropical grasses may be due to the environment under which they are grown rather than genetic differences.

An observation by Takeda and Fukuyama (1971) that vascular bundles occur closer together in tropical than in temperate grasses has implications both on digestibility and on growth efficiency. Reduced digestibility of tropical grasses, if it occurs, may be due to higher fiber contents which in turn may result from a larger number of vascular bundles per unit of leaf width. On the other hand more vascular bundles may be a distinct advantage in growth because of improved translocation.

Summary

Tropical grasses appear to be more productive than temperate species because of a more efficient photosynthetic mechanism. Associated with this increased photosynthetic efficiency is a clear cut difference in biochemical pathways, decreased photorespiration and a unique leaf anatomy. The main advantage of this new knowledge is to stimulate new ideas and approaches to research into increased productivity. Tropical and temperate grasses both have important roles in the economy of the southeastern United States. We need to improve productivity and utilization of both.

REFERENCES

1. Bassham, J. A. and M. Calvin. 1957. The Path of Carbon in Photosynthesis. Prentice-Hall. Englewood Cliffs, N. J. 104 p.
2. Chen, T. M., R. H. Brown and C. C. Black. 1970. Weed Science 18:399.
3. Chen, T. M., R. H. Brown and C. C. Black, Jr. 1971. Plant Physiol. 47:199.
4. Cooper, J. P. 1970. Herbage Abstracts 40:1.
5. Downes, R. W. 1969. Planta 88:261.
6. Downes, R. W. and J. D. Hesketh. 1968. Planta 78:79.
7. Downton, W. J. S. and E. B. Tregunna. 1968. Can. J. Bot. 46:207.
8. Edwards, G. E. and C. C. Black. 1971. Plant Physiol. 47:149.
9. Edwards, G. E., S. S. Lee, T. M. Chen and C. C. Black. 1970. Biochem. Biophys. Res. Comm. 39:389.
10. Hatch, M. D. and C. R. Slack. 1966. Biochem. J. 101:103.
11. Hatch, M. D., C. R. Slack and H. S. Johnson. 1967. Biochem. J. 102:417.
12. Hesketh, J. D. 1963. Crop Sci. 3:493.
13. Hesketh, J. D. and D. N. Moss. 1963. Crop Sci. 3:107.
14. Kortschak, H. P., C. E. Hartt and G. O. Burr. 1965. Plant Physiol. 40:209.
15. Minson, D. J. and M. N. McLeod. 1970. Proc. Eleventh Intern. Grassl. Long. p. 719-722.
16. Murata, Y. and J. Iyama. 1963. Proc. Crop Sci. Soc. Japan 31:315.
17. Murata, Y., J. Iyama and T. Honma. 1965. Proc. Crop Sci. Soc. Japan. 34:154.
18. Shatz, H. L. and L. N. Piemeisel. 1927. J. Agr. Res. 34:1093.
19. Takeda, T. and M. Fukuyama. 1971. Proc. Crop Sci. Soc. Japan 40:12.

Table. 1. Water requirement of some tropical and temperate grasses.

Tropical		Temperate	
Species	$\frac{\text{g water}}{\text{g D.M.}}$	Species	$\frac{\text{g water}}{\text{g D.M.}}$
Proso millet	267	Barley	518
Sorghum Spp.	305	Wheat	545
Corn	349	Oats	583
Gramagrass	338	Rye	634
Teosinte	362	Wheatgrass	857
		Bromegrass	977

From data of Shantz and Piemeisel (1927)

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Table 2. The CO₂ compensation concentration (ppm) of some tropical and temperate grasses.

Tropical		Temperate	
Species	ppm	Species	ppm
Bermudagrass	4	Tall fescue	45
Goosegrass	5	Italian ryegrass	41
Guineagrass	5	Reed Canarygrass	40
Dallisgrass	2	Quackgrass	52
Bahiagrass	5	Orchardgrass	>37
Crabgrass	1	Wheat	>37
Buffelgrass	5	Barley	>37
Johnsongrass	5	Oat	40

Data from Chen et al. (1970) and Downton and Tregunna (1968).

Table 3. Effect of oxygen on net photosynthesis of Tropical and Temperate grasses.

Tropical		Temperate	
Species	% increase*	Species	% increase*
Corn	0-6	Orchardgrass	46
Bahiagrass	2	Italian ryegrass	50
Foxtail millet	0	Reed Canarygrass	45
Rhodesgrass	3	Ky. Bluegrass	37
Sorghum	4	Wheat	50
Boer Lovegrass	0		

* Increase in net photosynthesis when O_2 was reduced from 21% to zero in atmosphere. Data from Downes and Hesketh (1968).

Table 4. Activities of carboxylating enzymes in leaf extracts of Tropical and Temperate grasses.

Species	PEP Carboxylase	RUDP Carboxylase
Tropical	μ moles/mg chl/hr	
Bermudagrass	680	170
Sugarcane	830	130
Corn	680	180
Temperate		
Tall fescue	21	380
Barley	14	296

Data from Chen et al. (1971)

Table 5. Activities of carboxylating enzymes in preparations from crabgrass leaves.

Preparation	Experiment No.	RUDP carboxylase	PEP carboxylase
CO ₂ , μ moles/mg Chl/hr			
Total leaf	1	150	250
	2	115	223
Mesophyll cells	1	12	635
	2	14	740
Bundle sheath cells	1	290	55
	2	225	54

Data from Edwards et al. (1970)

Grazing Trials on the Flatwoods of South
Central Florida
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A unique opportunity to do initial work on forage varieties and grazing management in a large geographic-agronomic area existed at the Range Cattle Experiment Station, Ona, in 1942. Improved varieties available were Carpetgrass, Common bahiagrass and Common bermudagrass. The bermudagrass had been discounted because of its known need for fertility and reputation as a weed in farmland. Pasture fertilization existed as a concept largely because the federal agricultural program assisted in clearing land, seeding, and fertilizing.

A tabular summary of early trials shows low acre gains and low daily gains. A pilot trial in the summer of establishment showed that a "shotgun" minor element treatment increased the grazing capacity of carpetgrass from 4 head on 5 acres to 10 head on the same acreage. Subsequent records showed a 41 percent acre gain response to the minor element treatment.

Work already done in Florida by Elaser, Stokes and others when this series of trials was begun, had established a pattern of 500 pounds per acre 6-6-6 as progressive pasture fertilization on carpetgrass. Other grasses became available in the 1940's for which there was no previous evaluation record. Among these were Pensacola and Argentine bahiagrass, Coastal bermudagrass, torpedograss and Pangola digitgrass. A three-year comparison under a single early spring fertilization with 30 pounds per acre each of N, P_2O_5 , and K_2O showed Pangola and Pensacola to be top producers with 152 and 202 pounds per acre gain respectively. Average daily gains of yearling steers averaged below one pound daily on carpetgrass and bahiagrass pastures and above this level on Coastal and Pangola. This was followed by a three year variety-fertilizer trial using 81-54-54 pounds N, P_2O_5 , K_2O per acre total, split between three equal warm season applications. Per acre gain on Pangola increased to 338 pounds, on Pensacola to 215 pounds and carpetgrass showed the largest percentage increase, to a total of 165 pounds. Daily gains per animal were little-changed by the fertilization rates.

The response to increased fertilization observed in this series called for more information on the effect of rate of fertilization on Pangola pasture. Four warm season dates of fertilization were used to furnish yearly nitrogen totals of 100, 200, and 300 pounds per acre with P_2O_5 and K_2O supplied to provide an overall 2-1-1 ratio.

Average annual per acre gains on the three ascending rates of fertilization were 300, 468, and 568 pounds on Pangola. A reference treatment run with Pensacola at the 200 pound nitrogen level averaged 343 pounds animal gain per acre. Daily gains were similar on the three fertilizer levels, averaging 1.28 pounds on Pangola and 0.84 pounds on Pensacola. Yearly variations were wide and though the experimental groups were in triplicate, only the four year duration of the trial made the averages valid.

Before these "new" grasses had been put through their evaluation—a new

popular variety demanded attention—a Digitaria valida accession known as "Giant Pangola." A full year of establishment preceded one spring and summer of grazing for record. The newcomer compared favorably with Pangola, but did not survive the grazing season!

A series of variety comparisons was begun in 1960, using an intermediate 200-100-100 annual fertilization pattern with four warm season application dates to utilize the relatively long growing season of the Florida peninsula. Pangola and Pensacola were check varieties. These were compared with Tifhi 1 bahiagrass, a hybrid developed by a Glenn Eurtan at Tifton, Georgia; Bermuda 52 and Slenderstem digitgrass, obtained by the Florida Agricultural Experiment Station through U.S.D.A. Cattle on Tifhi 1 gained approximately 10% more per acre than on Pensacola, with daily gain making most of the difference. Trying to get information available before the producer needs it does have some risks. Seed production problems kept Tifhi 1 from becoming available commercially.

Per acre beef production on the coarse-stemmed Bermuda 52 was unusually uniform over the five years of test. This grass was not an outstanding producer but daily gain of cattle was well above bahiagrass. It persisted well under rotational grazing and is still considered as having potential for diversification of grass varieties in an area where a broader species base for grass production is needed.

Slenderstem digitgrass in this trial proved to have good cattle performance values similar to Pangola and also had the insect and cold weather susceptibility of Pangola. Performance of Pangola was erratic during this trial, varying from 185 pounds animal gain per acre in 1962 to 641 pounds in 1961. Such variations are a part of grazing trials that can only be compensated for by years of record, since these were largely the result of seasonal weather and insect influences.

A five-year comparison of six grasses being grazed by yearling cattle throughout the year confirmed previous estimates of long-season use and yielded data on actual cool season relationships between grazing animals and certain grass varieties. Using the same check varieties and with all grasses fertilized twice annually to provide a 50-25-25 pounds per acre of N, P₂O₅, and K₂O, cattle production was similar to previous warm-season records. All pastures provided the minimum forage required for cattle during the winter, stocked at one head per acre, but supplement needs varied with variety. The digitgrass and bermudagrasses required fifty percent less concentrate feed in the cool season than the bahiagrasses. All average daily gains in this year-long trial were lower than in the warm-season experiments. Argentine bahiagrass was the lowest in average production on an acre basis during the cool season months. It should be noted that this same grass is favored by ranchers in locations within an hour's drive from the experimental area. The difference seems to be primarily temperature and serves as a caution against being dogmatic about the application of even the best grazing trials. This is an important note to be applied to all discussions of grazing results.

These grazing trials have provided a source of information for development of pasture and forage systems in the Florida peninsula. Tangible data and experience gained in management of the experiments both have made their contribution to the livestock industry. It should be made a final important note that the work reported has been a team approach involving numerous workers and more than one discipline.

AGRONOMIC AND NUTRITIONAL ASPECTS OF PRODUCING

COASTAL BERMUDAGRASS PELLETS

W. A. Balk
Clemson University

The inherently high feeding value of well fertilized Coastal bermudagrass is seldom reached with conventional systems of hay production because of the high incidence of unsatisfactory hay drying weather during the period of maximum growth. One approach to solving this problem is the use of dehydrating and pelleting equipment originally developed for the production of alfalfa pellets in the midwestern United States. With this equipment a system of production can be used to provide for a high degree of quality control and a finished product well adapted to mechanical handling.

Under normal procedure, the grass is cut with a forage harvester at the stage of growth deemed most desirable depending on the final usage. (Brood cows, steers or heifers, poultry, etc.). The chopped forage is then transported to plant where it is flash dried in a rotary dryer at temperatures up to about 300° F. The dried grass is then ground in a hammermill and finally extruded through holes in a ring die to form pellets.

Various sizes of pellets can be produced depending on the quality of grass, fineness of grind, moisture content, temperature and other factors. In general, as the size of pellets is increased the power required to form them is also increased. The industry usually produces pellets of $\frac{1}{2}$ " diameter as a standard size unless there is an impelling need for a larger pellet. The only situation where this seems to be necessary is with dairy cattle, where 5/16" grind size and 3/8" pellets are required to prevent a slight depression in butterfat content of the milk.

The finished product is in a form that can be handled by almost any kind of material handling equipment such as bucket elevators, screw conveyors, front end loaders, pneumatic conveyors, burlap sacks, paper bags, wash tubs or water buckets. Pellets can be safely stored in any place that is dry such as flat bottom bins, hopper bottom bins, barn floors, quonset huts and steel tanks.

I don't plan to talk about the engineering aspects of producing pellets, but I would like to take a few minutes to share with you the results of research relating some agronomic factors to the cost and quality of the pellets. I think that this information will be valuable to you, not because you may want to start a pelleting operation of your own, or even because you may want to advise someone else to do so; but rather because this information is applicable to the production of Coastal bermudagrass no matter how it is harvested. It applies to grass that

in cut for hay or for silage or even if it is harvested directly by the animals themselves, through grazing. Perhaps, we can look on the results of these pellet feeding tests as a goal to shoot for with the other means of harvesting. In this context, we are using the pelleting process as a means of controlling some of the otherwise uncontrollable variables that tend to obscure the results of a particular agronomic treatment. For example the effect of bad weather during harvesting is eliminated by artificial drying; and, in feeding tests wastage by the animals is minimized by using pellets.

As with any other commodity, the pellet industry has been concerned with ways and means of reducing the cost of production. I'm sure that you will agree that in agriculture we have no effective control over the prices we pay. That is, we have no control over the price we must pay for labor, financing, insurance, taxes, machinery, fertilizer, fuel and electric power, all of which are major inputs into any agricultural production system today. This means that if we are to reduce production costs it must be achieved through (1) improved management, (2) improved machinery, (3) agronomic (biological) adaptation.

By agronomic adaptation, I have in mind an improvement in production efficiency by the development of a better fit between a system of production and the constraints of its natural environment. This is primarily a systems engineering concept whereby an innovation is evaluated not merely in terms of its immediate and obvious response, but also in terms of its interaction with the entire system.

One of the major factors that influences the cost of processing Coastal pellets is the moisture content of the grass at the time it is harvested. This determines the number of tons per hour we can produce as well as the amount of fuel consumed in drying. It requires twice as much fuel to dry grass at 80% moisture as it does to dry grass at 65% moisture. There are two fairly obvious and easy ways to reduce this moisture content. We can wait until the grass is older before we cut it, or after cutting, we can let it wilt or partially dry in the field.

Research by others has shown that not only is the moisture content lower in older grass, but also the total (annual) yield is greater. Obviously the use of longer clipping intervals can reduce production cost per ton of dry matter by simultaneously increasing yield and decreasing moisture content. Additionally, the amount of field labor and machinery time per season is also reduced. On the other hand, nutritive quality decreases with maturity so that, inevitably, at some point loss in value will exceed savings in cost. The problem, then, is to determine the point at which this occurs.

In order to determine the optimum age for this grass when fed to yearling beef cattle we conducted an experiment in which steers were fed exclusively on Coastal pellets that had been harvested 21, 24, 27 and 30 days after the previous clipping. These steers were fed individually in a facility which was specifically designed for this purpose. Their daily feed intake was accurately measured, and the effect of differences in body weight and feed consumption were compensated for by statistical procedures.

The results of this experiment were evaluated in three ways. (1) The effect of grass maturity on cost of producing pellets. (2) The effect of maturity on the amount of grass required to produce a pound of beef. (3) These two estimates were combined into an overall cost index to determine the most

economical clipping interval for the combined system. Hopefully, this estimate will be valid regardless of price fluctuations.

Cost of producing the pellets was determined from a hypothetical situation using a reasonable acreage to establish cost per acre for growing the grass and cost per hour for harvesting and processing. Then the effect of maturity on yield, moisture content and numbers of harvests per season were used to determine plant output and unit costs as affected by age of grass. From these data a cost index was developed which is shown in figure 1 plotted against age of grass. In the course of developing this cost index it became apparent that this response is also valid for grass harvested as hay or as silage. This is so because of the relation of yield to maturity and because of the dominant influence of yield on cost per ton. This doesn't mean that the cost of producing a ton of pellets is the same as producing a ton of hay, but rather the effect of age on the cost of each product is the same.

The relative value of the grass as a feed was determined by the pounds of feed required to produce a pound of beef in the feeding experiment. This effect of age on quality is shown in figure 2, which also shows that the method of feeding can have an important effect on efficiency. Both of these curves were adjusted to equal daily intake and equal body weight for each animal on each treatment.

In figure 3 the cost index has been combined with the value index to determine optimum harvest age. As you can see, the two methods of feeding also influenced these results. The most economical grass maturity for the once daily feeding regime is 21 days. For twice daily feeding the optimum appears to lie between 24 and 27 days. In any case it is safe to say that grass should be harvested before it is 30 days old regardless of the method used for feeding it or for preserving it. It should be pointed out that mature brood cows could have a very different response curve; in fact it would be surprising if they did not.

The effect of field wilting on quality produced very similar results. In this case, however, production cost as shown in figure 4 did not drop off as rapidly--probably because yield was not involved here. On the other hand there was a consistent loss in quality as shown in figure 5. When these two curves are combined in figure 6 the result is a consistent increase in the cost index for producing a pound of beef as wilting time increased. Therefore field wilting does not pay off based on present prices for fuel and beef. These curves are also indicative of what happens to hay in the field curing process.

If we still have some time left, I would like to take a few minutes to try to convince you that we, in the South, are not taking advantage of the tremendous potential income that Coastal bermudagrass offers us. We have the technical ability right now to gross over \$600 per acre and furthermore, this can be done on wasteland such as Lakeland sand which is presently growing scrub oaks.

What I have in mind is a system whereby highly fertilized Coastal is harvested during the summer as hay or silage or pellets, whichever proves to be the most economical from a TON standpoint. Then feeding this to yearling steers (heifers) during the winter months in a conditioning program to increase their weight from about 450 lbs. to 750 lbs. They would be fed on the sod that the grass is harvested from, thus returning most of the mineral nutrients to the soil and eliminating the problem of waste disposal inherent in confinement feeding. Their

rate of gain can be controlled at optimum level by regulating the amount of corn used and depending on the price of beef relative to price of corn. An operation of this kind would require 7 to 10 steers per acre, depending on grass yield and amount of corn used. Multiply this by the number of acres that we have available and you can readily see that we do have a tremendous potential.

I hope that I've been able to convince you that we have some worthwhile data on how to produce beef from Coastal bermudagrass and that there is an opportunity to increase farm income substantially by better management of this very important crop. It has been a real pleasure to have this opportunity to present these thoughts to you this morning.

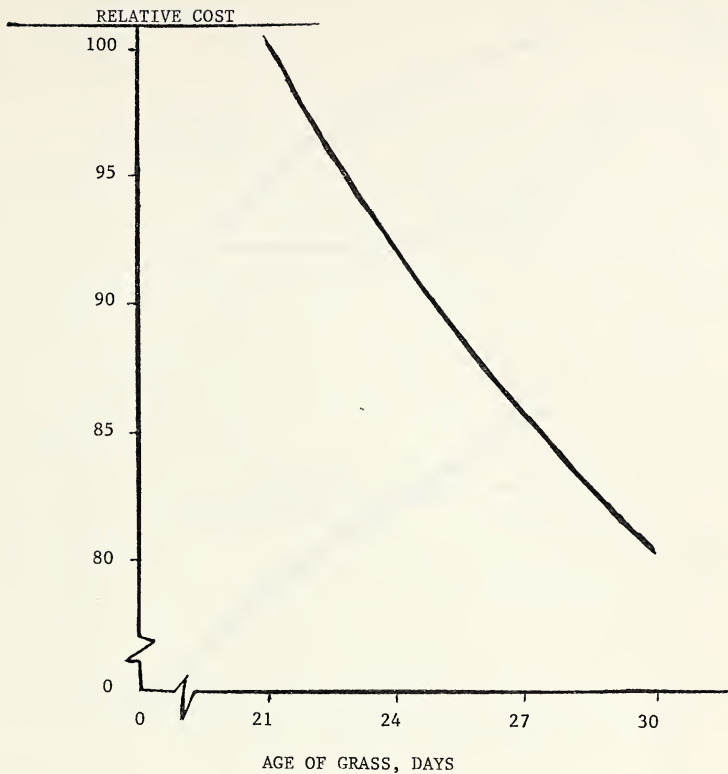


Figure 1. EFFECT OF MATURITY ON THE
RELATIVE COST OF PRODUCTION
OF DEHYDRATED COASTAL PELLETS

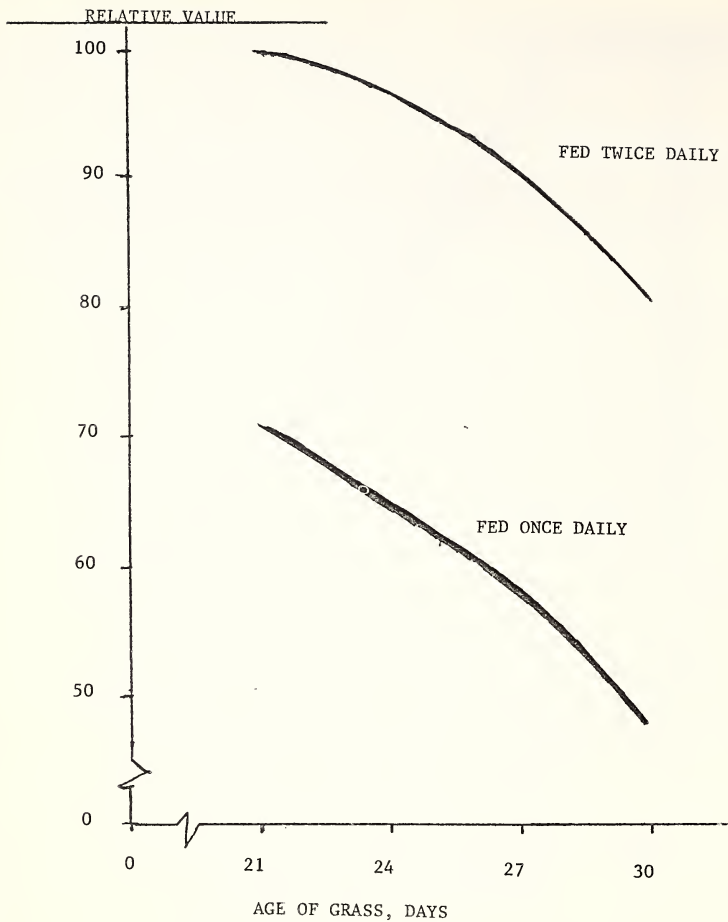


Figure 2. EFFECT OF MATURITY ON THE RELATIVE VALUE OF COASTAL BERMUDAGRASS FED TO BEEF STEERS

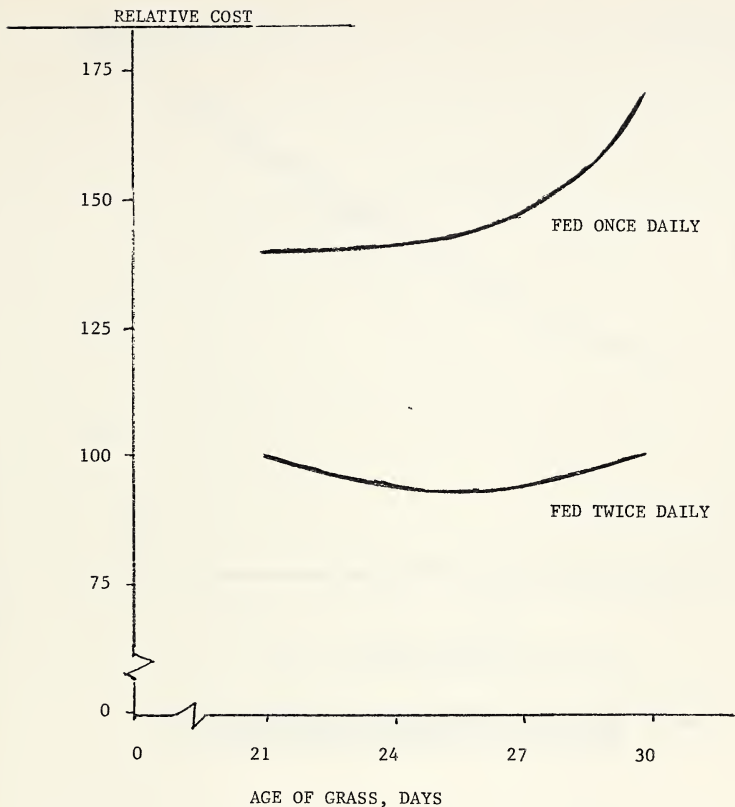


Figure 3. EFFECT OF MATURITY OF COASTAL BERMUDAGRASS ON THE RELATIVE COST OF WEIGHT GAINS OF BEEF STEERS

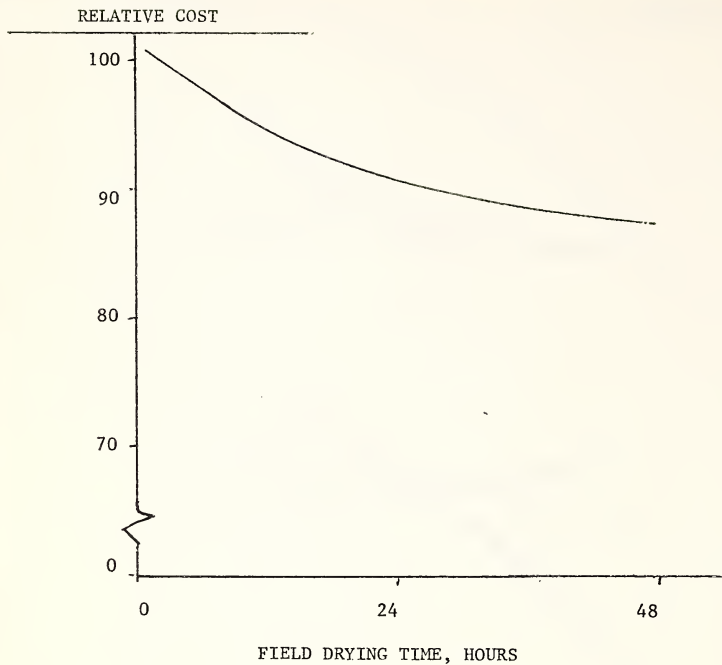


Figure 4. EFFECT OF FIELD WILTING ON RELATIVE COST OF PRODUCTION OF PELLETED COASTAL BERMUDGRASS

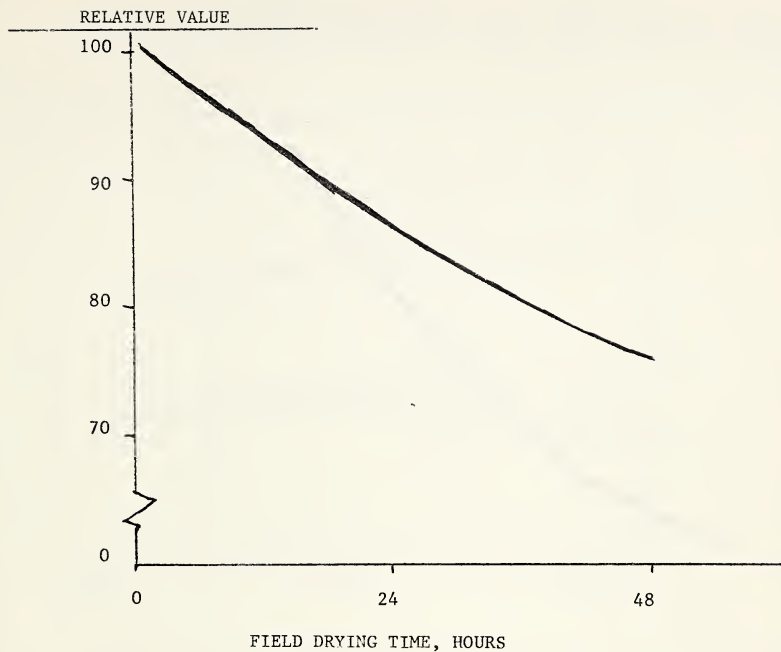


Figure 5. EFFECT OF FIELD DRYING TIME ON THE RELATIVE VALUE OF COASTAL BERMUDAGRASS FED TO BEEF STEERS

RELATIVE COST

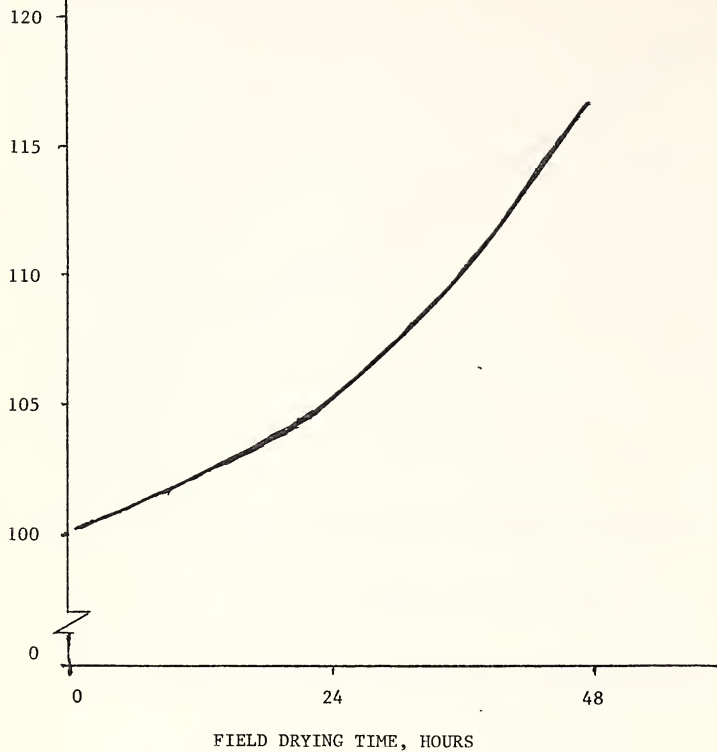


Figure 6.

EFFECT OF FIELD WILTING ON THE RELATIVE COST OF
WEIGHT GAINS OF BEEF STEERS

Figure 1. - Percent total beef production was of total consumption, North Carolina, South Carolina, and Georgia, 1950, 1960, 1970, and 1971.

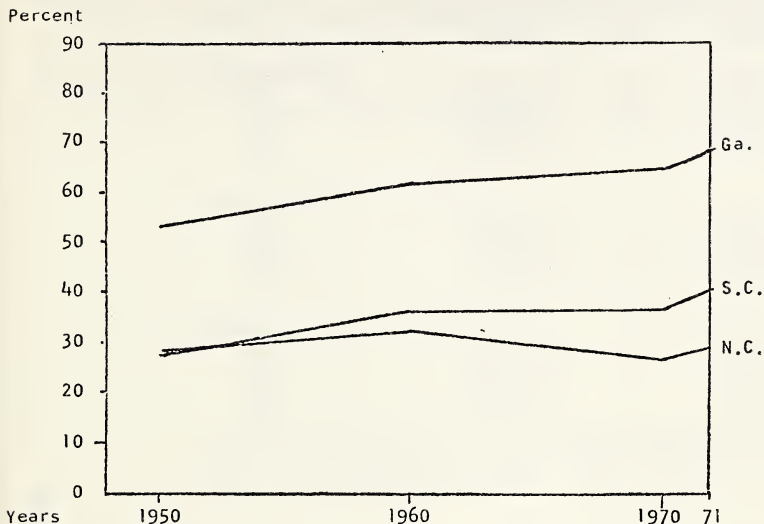
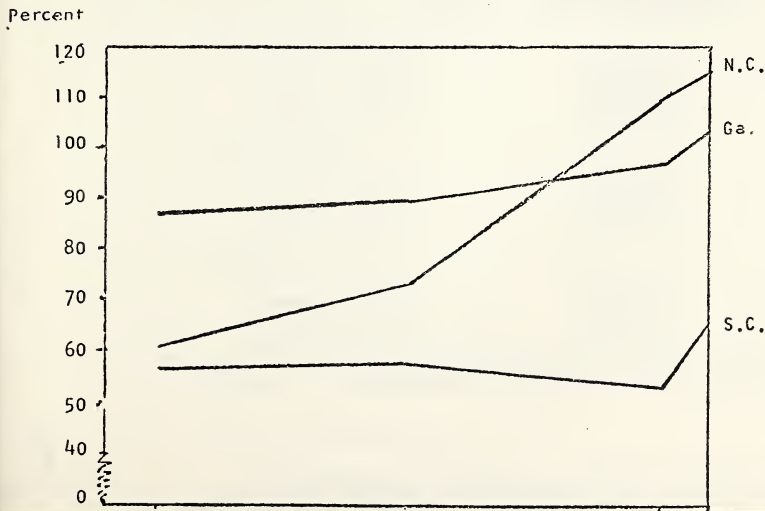


Figure 2. - Percent total pork production was of total consumption, North Carolina, South Carolina, and Georgia, 1950, 1960, 1970, and 1971.



Source.

USDA, Meat Animals, Farm Production, Disposition, and Income by States, 1969-1970, Mt. An. 1-1 (71), Statistical Reporting Service, Washington, D. C., April, 1971, pp. 7 and 8. - Agricultural Statistics, 1961, pp. 318 and 330, and Agricultural Statistics, 1952, pp. 390 and 410, also Mt. An. 1-1 (72) pp. 7 and 13.

Based on "Food Consumption, Prices, Expenditures," Supplement of Agricultural Economic Report No. 138, January, 1970, p. 80 and on Agricultural Statistics, 1971, p. 362 and Agricultural Statistics, 1961, p. 366.

Table 1. - Acreage and production of corn for grain for North Carolina, South Carolina, and Georgia, Years 1950, 1960, 1970, and 1971

	Acreage harvested acres	Total production bushels
<u>North Carolina</u>		
1950	2,248,000	74,184,000
1960	1,938,000	96,900,000
1970	1,400,000	70,000,000
1971	1,520,000	86,640,000
<u>South Carolina</u>		
1950	1,446,000	26,320,000
1960	842,000	28,207,000
1970	402,000	10,854,000
1971	454,000	24,516,000
<u>Georgia</u>		
1950	3,259,000	49,536,000
1960	2,644,000	84,608,000
1970	1,426,000	44,206,000
1971	1,532,000	85,792,000

Source: Agricultural Statistics, 1951, 1961, and 1971.

Table 2. - Total population for North Carolina, South Carolina, and Georgia, Years 1950, 1960, and 1970

	Total population
<u>North Carolina</u>	
January 1, 1950	4,076,000
January 1, 1960	4,577,000
January 1, 1970	5,082,059
January 1, 1971	5,160,323
<u>South Carolina</u>	
January 1, 1950	2,116,000
January 1, 1960	2,395,000
January 1, 1970	2,590,516
January 1, 1971	2,613,123
<u>Georgia</u>	
January 1, 1950	3,443,000
January 1, 1960	3,959,000
January 1, 1970	4,589,000
January 1, 1971	4,664,798

Source: U. S. Department of Commerce, Bureau of the Census.

Table 3. - Production and consumption of beef on a dressed weight equivalent for South Carolina, North Carolina, and Georgia, Years 1950, 1960, 1970, and 1971.

State	YEAR 1950			YEAR 1960		
	Total production 1/ 1,000 lbs.	Estimated total consumption 2/ 1,000 lbs.	% production was of consumption	Total production 1/ 1,000 lbs.	Estimated total consumption 2/ 1,000 lbs.	% production was of consumption
C.	31,368	115,378	27.2	63,494	175,314	36.2
C.	60,975	221,375	27.5	108,671	334,963	32.4
C.	100,167	187,730	53.4	178,884	289,726	61.7

State	YEAR 1970			YEAR 1971		
	Total production 1/ 1,000 lbs.	Estimated total consumption 2/ 1,000 lbs.	% production was of consumption	Total production 1/ 1,000 lbs.	Estimated total consumption 2/ 1,000 lbs.	% production was of consumption
C.	95,106	253,300	37.6	106,366	255,511	41.63
C.	136,587	496,924	27.5	145,772	504,576	28.89
C.	291,984	448,768	65.0	315,327	456,124	69.13

Per capita beef consumption = 54.5 pounds in 1950, 73.2 pounds in 1960, and 97.78 pounds in 1970 and 1971.

Table 4. - Production and consumption of pork on a dressed weight equivalent for South Carolina, North Carolina, and Georgia, Years 1950, 1960, 1970 and 1971.

State	YEAR 1950			YEAR 1960		
	Total production 1/ 1,000 lbs.	Estimated total consumption 2/ 1,000 lbs.	% production was of consumption	Total production 1/ 1,000 lbs.	Estimated total consumption 2/ 1,000 lbs.	% production was of consumption
C.	86,984	153,908	56.5	94,400	163,100	57.9
C.	181,066	295,302	61.3	228,233	311,626	73.2
C.	216,606	250,420	86.5	239,573	269,540	88.9

State	YEAR 1970			YEAR 1971		
	Total production 1/ 1,000 lbs.	Estimated total consumption 2/ 1,000 lbs.	% production was of consumption	Total production 1/ 1,000 lbs.	Estimated total consumption 2/ 1,000 lbs.	% production was of consumption
C.	96,174	180,610	53.3	120,026	182,187	65.88
C.	390,337	354,321	110.0	414,018	359,778	115.08
C.	311,599	319,985	97.4	336,556	325,230	103.48

Per capita pork consumption = 72.7 pounds in 1950, 68.1 pounds in 1960, and 69.72 pounds in 1970 and 1971.

Overseeding winter annual forages in perennial warm-season grasses can be a profitable technique for increasing forage profits for the cow-calf enterprise. Net profits of \$50 to \$75 per acre are realistic in efficient forage production and utilization enterprises. This represents considerable economic increase in the southern forage economy.

Before reviewing the specifics of successful overseeding, a brief review of the current pasture-livestock situation is in order.

INTRODUCTION

A large majority of pasture acreage in the South consists of warm-season perennial forages. At their best, these forages are barely adequate to meet the nutritional demands of the cow and calf. Results are that low calving percentages, low weaning weights and low forage profits are typical among the average southern forage producers.

Maddox (1966) has summarized the seasonal nutrient requirements of the cow and calf, as shown in Figure 1.

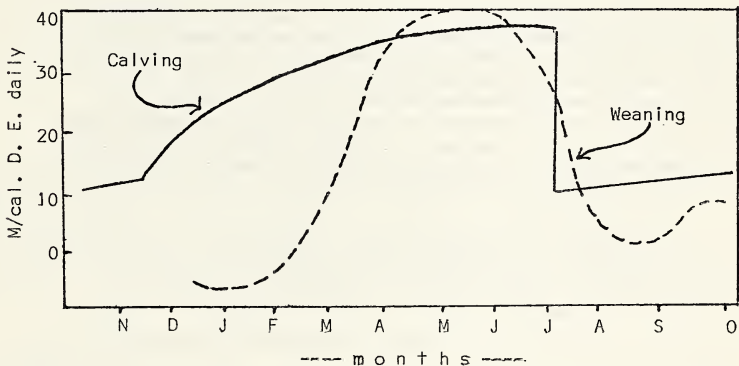


Fig. 1. Nutrient requirements and perennial warm-season forage production.

The typical forage program results in late-winter or spring-born calves. Even with fertilization, forage production and quality of warm-season perennials does not consistently meet the nutrient requirements of growing calves, especially in summer months of July and August. Thus, the resulting product is a light-weight calf for sale in the fall months when prices are usually lower.

The southern forage producer must improve forage production practices to the extent that stocking rates can approach 1 cow per acre for 365 days a year. Calf weaning weights and calving percentages must also be increased if maximum acre pasture profits are to be realized. Table 1 shows that calf weaning weights and stocking rate have more influence on pasture income than a 5-cent-per-pound increase in calf sale price.

Table 1. Effect of forage consumption and stocking rate on beef income.

Acres per cow	Forage consumed (tons per acre)	Gross income per acre*	
6	1	\$ 25	\$ 30
4	1½	37	45
3	2	50	60
2	1	75	90
1	6	150	180

*600-lb. calf, 25¢/lb. and 30¢/lb.

Lippke (1968) has demonstrated visually that cool-season forages are characteristically higher in digestibility than warm-season perennials. The need for higher quality forages to extend the grazing period has been widely recognized. Researchers and commercial forage and live-stock producers have attempted to provide better quality forage during fall, winter and spring months primarily through prepared seedbeds, small grain forages, pastures, or by overseeding areas of perennial warm-season sod. Results have been erratic, but usually costly. The increase in saleable products has not met or greatly surpassed the expense of forage production.

A dependable supply of cool-season forage for November, December and January grazing, combined with good-quality warm-season forage in the spring could provide nine or more months of adequate nutrition for the cow-calf enterprise. An adequate supply of such a high-quality forage program should enable crossbred cows to wean 600-pound calves by nine months of age.

Thus, we see several benefits of overseeding: 1) Extended grazing season. 2) Reduced amounts of hay and supplement. 3) Higher quality forages. 4) Utilization of forage with the most efficient kind of animal. 5) More potential profits for forage producers. 6) Conservation of soil and water. 7) Lengthen the effectiveness and importance of high-producing warm-season perennial pastures, such as Coastal bermudagrass.

In this presentation, overseeding may be defined as "the establishment of cool-season annual forages in perennial warm-season pastures." Major species are clovers, small grain or cereal grain, and ryegrass. Perennial species, such as tall fescue, is usually considered in renovation, and is not discussed in this paper.

EARLY RESEARCH

Overseeding, or sodseeding, has been and is being developed in the United States, New Zealand and Australia. Emphasis mushroomed in the post-World War II era. Blackmore (1958) in New Zealand, Breakwell and Stephans and Marchant (1958) reported on contemporary research. Early efforts were devoted for forage, as well as grain production from small grains. Welch, Wilkinson and Hillsman (1967) reported grain yields of rye in Coastal bermudagrass sod to be as high as yields when seeded in prepared seedbeds. Forage yields usually have not been as encouraging. Elder and Tucker (1968) reported that sodseeded grain yields at several locations in Oklahoma compared favorably with nearby prepared seedbed yields of wheat, table 2. Sixty pounds per acre of nitrogen appears to

Table 2. Overseeding wheat in bermudagrass, Muskogee, Oklahoma.*

Treatment	Yield per acre
0 nitrogen	17 bu.
80 lb. nitrogen	41 bu. + 3 tons bermudagrass + hay + 50 days grazing

*From Elder and Tucker (1968)

be the most practical rate. When favorable moisture is present, 80 pounds of nitrogen per acre produced 41 bushels per acre of wheat compared to 17 bushels per acre without nitrogen at the Muskogee Station. After combining 41 bushels of wheat, the bermudagrass and wheat straw was mowed. Three tons of hay was harvested and 50 days of grazing was available during September and October before overseeding the next year's crop.

The quality-improving benefits of legumes are important in addition to nitrogen fixation ability. Holt and Lancaster (1968) showed that legumes overseeded in Coastal bermudagrass can produce $1\frac{1}{2}$ to 2 tons more forage annually than Coastal bermudagrass alone, table 3. Craigsmiles and Weihsing (1971) reported that white clovers and Gulf ryegrass were consistently the highest forage producers in their tests.

Hogg and Collins (1965) have found that winter legumes in perennial pastures improve beef gains, weaning weights, calving percentages and

pasture profits. Hoveland (1972) reported highest calf gains and most grazing days from Coastal bermuda-Yuchi arrowleaf clover than from other clovers in the test. Adams and Stelly (1958) reported that inclusion of crimson clover with Coastal bermudagrass increases the total annual forage production by the weight of clover and provided earlier forage than grass alone.

Table 3. Effect of legumes on Coastal bermudagrass yield.*

Treatment	Pounds N/A	T.A.D.F./A		
		'58	'59	'60
Legume	120	5.7	5.9	5.7
No legume	120	4.3	4.4	3.6
Legume	90	5.4	5.6	5.5
No legume	90	3.9	4.2	4.4
LSD		.6	.9	.8

Hoveland (1961) and others report that overseeding on dallisgrass-white clover pastures is of doubtful value where good stands of white clover are present. Where satisfactory stands of white clover are not maintained, total forage yields of small grains were only slightly better than kale peas, but provided considerably earlier production in the fall.

Johnson reported on an experiment initiated in 1954 to evaluate seeding rates, drill widths, and fertilization levels for overseeding wheat in permanent warm-season sod. Seeding rates were 30, 60, and 90 pounds per acre; drill widths were 8, 12, 16, 20 and 24 inches. All plots received 60-60-60. He concluded that the seeding rates for sod seeding should be at least equal to the rate in a conventionally prepared seedbed. A narrow row (less than 16 inches) spacing should be used for earlier forage production.

Early equipment was developed to drill seed of winter forage species in uniform widths in sod. Efforts were made by equipment manufacturers to minimize damage to the warm-season sod. In fact, one equipment manufacturer boasted that "the sod is not destroyed, and after a rain you can hardly tell the equipment went through the sod."

Riewe and Smith (1952) in Texas as early as 1952 reported highly significant increases in oat-forage production on a dallisgrass sod when nitrogen and phosphorus were added in combination.

Fisher (1972) during 1955 and 1956 planted small grain in a high-fertility Coastal bermudagrass experiment. Satisfactory stands were not obtained until nitrogen levels reached 800 pounds or more per acre. Establishment was not obtained until late in the fall after Coastal bermudagrass became dormant.

Adams and Stelly (1958) found that as nitrogen application to Coastal was increased, the soil pH values and available potassium content decreased and the production of crimson clover was reduced, especially during the second harvest year.

Adams and McCreery (1959) in Georgia showed a 50 percent increase in crimson clover forage production when 50 pounds of phosphorus was applied. Potash application of 200 pounds per acre produced 8 times more clover forage than no potash fertilization, table 4. Nutrient con-

Table 4. Response of crimson clover to phosphorus and potash fertilization.

	Percent nutrient in plant at			
	pounds per acre			
	0	50	100	200
P	.23	.30	.34	.38
K	1.2	1.2	1.7	2.2

From Adams and McCreery (1959)

tents of these two elements in plant tissue was increased from a borderline deficiency to a satisfactory level. They concluded that: 1) the first 50 pounds of phosphorus produced the greatest increase of clover, 2) 100 pounds N per acre increased forage production from crimson clover, 3) increasing rates of potash increased total uptake of both phosphorus and potash in plant tissue, 4) potash was the one nutrient most frequently limiting the stand and production of crimson clover.

Seasonal growth of species and varieties, as well as animal grazing days per acre is important to the forage and livestock producers. Early fall growth of adequate quality forage is necessary if August and September calves are to grow rapidly through winter months and wean 600 to 700 pounds by June or July. Perennial cool-season species, such as fescue and ladino clover, have provided more animal grazing days than certain overseeded species. Also, the date for grazing initiation has been

earlier. The dry forage yields have also been consistently higher, according to Ukkelbert, et al (1966) and others in Georgia on Bladen soils in the Atlantic coast flatwoods.

Table 5 shows the average date that sufficient forage was available for grazing was November 20 for fescue - ladino clover; January 14 for overseeded rye; February 14 for overseeded ryegrass and March 16 for volunteer crimson clover. Stocking rate for the forage system was 1.6 acres per cow, and cows weaned 81 percent calf crop in this experiment.

Table 5. Grazing season of winter forages.

Forage	Animal days grazing						
	N	D	J	F	M	A	M
Fescue-ladino	27	19	16	5	11	24	10
Sodseeded rye			16	28	18	17	8
Sodseeded ryegrass				14	17	22	16
Voluntary crimson					17	13	7
							37

From Ukkelberg, et al (1966)

Thompson, Johnson and Jones (1961) in Mississippi reported that wheat in a prepared seedbed produced approximately twice as much forage as wheat overseeded in bermudagrass sod. Approximately 2/3 of overseeded wheat was produced after March 1, as shown in table 6. They reported that early winter grazing cannot be expected from sod-seeded small grain, and that the practice should be used as a supplement rather than replace winter grazing on prepared seedbed. Seed planted on 8-inch drill spacing consistently provided a larger percentage of forage before March 1 than seed planted on 16- or 24-inch drill spacings.

Table 6. Forage yield and earliness, prepared seedbed and sod-seeded.

Seeding date	Percent harvest by March 1	
	Sod-seeded	Prepared
September 15	27 - 0	76 - 24
September 30	25 - 0	51 - 31
October 15	30 - 0	38 - 10
October 30	26 - 0	22 - 0

From Thompson, et al (1961)

Patterson and others (1959) in Alabama reported that a mixture of oats and crimson clover on prepared seedbed was ready for grazing on November 13, 1957, table 7.

Table 7. Production of forage mixtures.

	Days	Steers	Gain	Forage
Seedbed				
Oats - clover	122	1.5	445	4207
Rye - ryegrass-clover	144	1.5	445	6083
Sod - Seeded				
Rye - clover-Coastal	118	.9	322	4580
Rye - dallis - W. Clover	98	1.3	291	4322
From Patterson et al (1959)				

Rye and crimson clover overseeded on Coastal bermudagrass was not stocked until the following March. The overseeded pasture appeared to contain considerable quantities of frosted bermudagrass. Although both mixtures on prepared seedbed produced 100 pounds more beef per acre than over-seeded crops, animal performance was fairly satisfactory, considering the lateness when grazing was initiated on the overseeded pasture.

Hart and Burton (1965) computed multiple regression equations and developed frequency distributions of total yield and yields during winter months of oats, rye and wheat. The best equations were associated with r square values of .96, .91 and .93. The equations included date of harvest, accumulated rainfall, solar radiation and temperature as independent variables. These equations are valuable for estimating the fluctuations and rate of small grain growth caused by variations in weather conditions.

Considerable research to simplify and encourage early forage growth from reseeding has been conducted in recent years. Knight (1967) in Mississippi reports that satisfactory voluntary stands and yields of crimson clover were produced when 40 pounds or more pounds of seed were shattered in the spring during reseeding. Under the conditions of his test fall disking caused highly significant reduction in clover yields with a greater reduction on a percentage basis at the lower seeding rate. Nitrogen reduced stands and yields of clover components, but not significantly.

Donnelly and Cope (1961) state that maintaining reseeding stands of crimson clover depend on four factors: 1) fertility of the soil, 2) intensity of grazing, 3) competition from summer vegetation and 4) infestation of insects and diseases. They advise close grazing or mowing in late summer and point out that light disking before frost is often beneficial in reducing grass competition and providing an early fall stand of clover.

Hoveland and others (1971) report that the amount of grass stubble greatly affects growth of winter annual clover in perennial grass pastures, table 8.

Table 8. Effect of stubble height on clover stands and yields.

	<u>Arrowleaf</u>		<u>Crimson</u>	
	<u>Plants</u>	<u>Yield</u>	<u>Plants</u>	<u>Yield</u>
Bahia				
1 in.	17	2290	25	1070
3 in.	18	1620	24	780
6 in.	14	1350	20	430
Coastal				
1 in.	20	2930	27	1540
3 in.	29	2890	34	1620
6 in.	30	2800	31	2020

From Hoveland, et al. (1971)

The effect varies among summer grasses and winter legumes. Yuchi arrowleaf clover grew better than crimson clover at all stubble heights of 1, 3 and 6 inches, which were tried in the tests. Pensacola bahia was more restrictive to clover growth than Coastal bermudagrass, regardless of stubble height. Vetch seedlings can penetrate tall stubble, but provide limited grazing and quality. The shorter stubble height provided more plants and higher forage yields than the 3- or 6-inch stubble height of bahiagrass. The apparent beneficial effect of 6-inch stubble height in Coastal bermudagrass was due to a thin stand, which provided protection for germinating seedlings. The authors state that heavy bermuda sod can be expected to reduce clover growth unless stubble is removed.

Johnson (1958) observed that seedling plants could not successfully compete with the established warm-season perennial forages while these species were actively growing. Thus, he initiated three treatments to

determine effect of retarding warm-season forages: 1) clipping, 2) no clipping, 3) chemical, dinitroamine. Both treatments retarded topgrowth of warm-season species temporarily. However, these treatments did not deter root action of perennial species, and prevented the seedlings from developing to any extent until the usual time of winter dormancy.

Ross and Cocks in Australia (1964) reported the desiccants diquat and paraquat have provided a major tool for oversowing rundown pastures. They found from a large number of trials that grazing intensity both before and after overseeding can mean the difference between success and failure. They recommend grazing (hard grazing) of the spring growth to remove topgrowth by autumn. After seeding, grazing should prevent any recovering forage from shading out the newly sown grasses. They recommend grazing intensity so that warm-season species never exceed two to three inches height.

Elder and Tucker (1968) compared the effect of a chemical and disking to retard bermudagrass in the fall and permit earlier growth of winter annual. They found that 60 pounds or more of nitrogen was needed to give winter forage growth comparable to that produced by disking or by chemical retardation, table 9.

Table 9. Wheat forage from overseeding on bermudagrass sod.

Nitrogen	Pounds forage per acre		
	None	Chemical	Disk
0	384	1150	1150
30	766	1630	1758
60	1054	2205	1980
90	1438	1980	2205
120	1726	2190	1822

From Elder and Tucker (1968)

Investigations in the past four years at the Texas A&M University and Agricultural Research and Extension Center at Overton have included: 1) desiccation with liquid nitrogen (32% solution) at high rates of N and 2) desiccation with chemical paraquat. Stands and growth of winter annuals were comparable at high rates, 100 plus pounds of N and paraquat desiccation. However, results during the 1971-72 season are complexing: 1) bermudagrass sod has been thickened during the 3 years of high fall and winter fertilization and 2) climatic conditions in fall of 1971 favored bermudagrass growth. Although the two factors have reduced winter forage growth, Rouquette (1972) estimates that overseeded small grain-ryegrass can provide adequate grazing for 1 cow per acre during the late

fall and winter months. McCartor and Taylor (1970) reported that wheat-ryegrass pastures provided grazing from early November through mid-May. Heifer gains on pasture were 14 cents per pound compared to 25 cents per pound on bermudagrass hay plus supplement. Gains on overseeded pasture were favorable, but less than gains on prepared seeded pasture.

Matocha (1972) showed that wheat-ryegrass overseeded in Coastal bermudagrass reduced production of Coastal during early summer, but did not significantly affect production in mid-to-late summer. He also reported that bermudagrass can immobilize 80 to 100 pounds per acre of N, due to its high requirement for this nutrient. Matocha recommends a 240-120-200 total fertilizer application for overseeded wheat-ryegrass in bermudagrass sod.

Extension demonstrations in specific areas of Texas have shown that overseeding ryegrass and clovers in perennial pastures can provide sufficient quality and grazing in adequate amounts to support one cow and calf per acre. Stands of perennial species--warm and cool season--improve each season. Stocking rates are approximately one cow per acre. Cows are calving on less than 12-month intervals. Weaning weights are approaching 600 pounds calf per acre, even on November and December calving schedules. One demonstration still is stocked with 500 cows plus their calves on 500 acres. Forage consists of Gulf ryegrass and Yuchi clover overseeded into Common bermudagrass sod. Soil was scarified and received 600 pounds of 9-23-30 in October when annual forages were planted. Additional applications of 200 pounds of 33-0-0 per acre were made in fall and winter. The inherent fertility of soil was very low. Weaning weights for steer calves was 517 pounds; heifers was 475 pounds. Forage income through calf production was \$175.28 per acre in 1971. Earlier demonstrations, approximately 30 acres in size, showed profits approaching \$50 per acre, when calf prices were 24 to 26 cents per pound, tables 10 and 11.

Table 10. L. J. McNeil, Brazoria County, Texas,
Pilot Pasture Demonstration.

	Y E A R		
	First	Second	Third
Income	\$56.07	\$88.28	\$85.48
Expenses	38.95	42.65	44.13
Returns	\$17.12	\$45.63	\$41.35

Table 11. Bill Clements, Gregg County, Texas,
Pilot Pasture Demonstration.

	Y E A R		
	<u>First</u>	<u>Second</u>	<u>Third</u>
Income	\$83.96	\$106.65	\$108.22
Expenses	<u>52.07</u>	<u>72.00</u>	<u>58.39</u>
Returns	\$31.89	\$ 34.65	\$ 49.83

Thompson and workers (1965) have developed recommendations for renovating grass fields in Kentucky. Major emphasis includes clover in perennial cool-season forages, such as tall fescue.

Johnson and Gurley (1965) list several steps for overseeding small grains in bahia or bermudagrass sods in Georgia. Simmons (1972) reports that success or failure of overseeding is usually attributed to good or bad management of the controllable factors.

If overseeding is to become a widely accepted practice among forage producers in the South, techniques and recommendations must be developed which will provide a dependable forage system to include early and sustained grazing for the beef cow herd. Forage from overseeding most likely will be two to three weeks later than forage produced on prepared seedbed. High-quality warm-season perennials which have been fertilized in late summer and early fall can supply most or all nutrient requirements of the cow with a young calf. A system including limited grazing of the overseeded winter annuals can be adopted.

At present, our concept of successful and dependable overseeding techniques include: 1) Remove perennial grass forage by grazing, shredding, or harvesting for hay during late August or early September. 2) Scarify the soil by disking or other methods to expose 50 or more percent of the soil surface. This should be done by September 15 to 20. 3) Apply 50 pounds of nitrogen plus phosphorus, potash and lime as recommended by a soil test. 4) Plant adapted species. We recommend Gulf ryegrass in all mixtures. 5) When winter species have germinated and are up to a stand, topdress 100 pounds of nitrogen. This usually is October 5 to 15. 6) Begin grazing when cool-season forages have become rooted satisfactorily or as warm-season perennials regrow and threaten active growth of overseeded species. 7) Use approximately 1/2 acre per cow. 8) On an adjoining 1/2 acre per cow, fertilize warm-season perennial species heavily in mid-to-late August to provide forage until frost or overseeded area is ready.

We can develop overseeding techniques for assuring dependable and profitable amounts and quality of forage to wean feeder calves--not stocker calves--from fall calving dates in southern pastures. We can and must do this if the South is to not only maintain but accelerate its importance in forage and beef production to feed this Nation.

And I have full confidence that we right here in this room--working jointly in team efforts with associates--will perfect this and improve forage systems because we are dedicated and sold out to the betterment of forages, pastures and grasslands in our Nation.

LITERATURE CITED

- Adams, W. E. and M. Stelly. 1958. A comparison of Coastal and Common bermudagrass (Cynodon dactylon) in the Piedmont Region: I. Yield response to fertilization. Agron. J. 50:457-459.
- Adams, W. E. and R. A. McCreery. 1959. What are the fertility needs of crimson clover when grown with Coastal bermudagrass ... and Coastal bermudagrass grown alone? Better Crops With Plant Food.
- Blackmore, L. W. 1958. Overdrilling of pastures and crops. New Zeal. J. Agr. 96: 17-19.
- Breakwell, N. J. and H. V. Jenkins. 1953. A pasture overseeding implement. J. Austral. Inst. Agr. Sci. 19:109-110.
- Craigsmiles, J. P. and R. M. Weihing. 1971. Temporary winter pasture studies in the Gulf Coast rice belt. Tex. Agri. Exp. Sta. MP-990.
- Decker, A. M., H. J. Retzer, F. G. Swain and R. F. Dudley. 1969. Midland bermudagrass forage production supplemented by sod-seeded cool-season annual forages. Maryland Agri. Exp. Sta. Bul. 484.
- Donnelly, E. C. and J. T. Cope, Jr. 1961. Crimson clover in Alabama. Auburn Univ. Agri. Exp. Sta. Bul. 335.
- Dudley, R. F. and L. N. Wise. 1953. Seeding in permanent pasture for supplementary winter grazing. Mississippi Agri. Exp. Sta. Bul. 505.
- Elder, W. C. and B. B. Tucker. 1968. Over-seeding small grains in bermudagrass sod for grain production. Processed Series P-592.
- Fisher, F. L. 1972. Personal communication.
- Hart, R. H. and G. W. Burton. 1965. Effect of weather on forage yields of winter oats, rye and wheat. Agron. J. 57:588-591.
- Hogg, P. G. and J. C. Collins. 1965. Beef production of Coastal bermuda with legumes and nitrogen on heavy clay soils in the Mississippi Delta. Mississippi Univ. Agri. Exp. Sta. Information Sheet 889.
- Holt, E. C. and J. A. Lancaster. 1968. Bermudagrass production and management in East Texas. Tex. Agri. Exp. Sta. Bul. 1073.
- Hoveland, C. S., E. L. Carden, J. R. Wilson and P. A. Mott. 1971. Summer grass residue affects growth of winter legumes under sod. Alabama Agri. Exp. Sta. Rep. Vol. 18, No. 3.
- Hoveland, C. S., L. A. Smith and H. W. Grimes. 1961. Forage production of winter annuals sod-seeded on Dallisgrass-White Clover. Auburn Univ. Exp. Sta. L-66.

- Hoveland, C. S., W. B. Anthony, E. L. Mayton and H. E. Burgess. 1972. Pastures for beef cattle in the Piedmont. Auburn Univ. Agri. Exp. Sta. Cir. 196.
- Johnson, C. M. 1958. New tests add information on sod seeding. Mississippi Agri. Exp. Sta. Mississippi Research.
- Johnson, J. R. and W. H. Gurley. 1965. Winter grazing in Georgia. Georgia Cooperative Ext. Ser.
- Knight, W. E. 1967. Effect of seeding rate, fall disking and nitrogen level on stand establishment of crimson clover in a grass sod. Agron. J. 59:33-37.
- Lipke, H. 1968. Proceedings of the Third Annual Pasture and Forage Crops Shortcourse. Tex. A&M Univ.
- Maddox, L. A. 1966. Nutrient requirement of the cow and calf. Tex. Agri. Exp. Sta. Bul. 1044.
- Matocha, J. E. 1972. Production of wheat-ryegrass and Coastal bermudagrass grown in association as affected by rates and sources of nitrogen. Overton Tex. Agri. Exp. Sta. PR-3015.
- McCartor, M. and W. Taylor. 1970. Wheat-ryegrass pasture for feeded cattle production in East Texas. Overton Tex. Agri. Exp. Sta. PR-2731.
- McCartor, M. 1972. Personal communication.
- Patterson, R. M., W. B. Anthony and V. L. Brown. 1959. Pasture know-how from winter grazing trials. Auburn Agri. Exp. Sta. Rep. Vol. 6, No. 3.
- Riewe, M. E. and J. C. Smith. 1952. Seeding oats on an established dallis and bermudagrass sod. Tex. Agri. Exp. Sta. PR-1487.
- Ross, M. A. and P. S. Cocks. 1964. Grazing is vital in pasture oversowing. J. of Agri. Rep. L-3768.
- Rouquette, F. M., Jr. 1972. Personal communication.
- Simmons, G. D. 1972. Sod-seeding of small grains. The Samuel Roberts Noble Foundation, Inc., Ardmore, Oklahoma.
- Stephans, J. L. and W. H. Marchant. 1958. The influence of irrigation, rates of nitrogen and interplanted crops on forage production of Coastal bermudagrass. Georgia Agri. Exp. Sta. Cir. N.S. 12.
- Thompson, W. R., Jr., C. M. Johnson and T. N. Jones. 1961. Sod Seeding. Mississippi Univ. Agri. Exp. Sta. Information Sheet 728.
- Thompson, W. R., Sr. 1955. Sod Seeding. Mississippi State College Ext. Ser. Pub. 294.

Ukkelberg, H. G., B. L. Southwell and F. L. Long. 1966. Winter pastures for beef cattle on heavy bladen and associated soils of the southeast. Georgia Agri. Exp. Sta. Cir. N.S. 47.

Welch, L. F., S. R. Wilkinson and G. H. Hillsman. 1967. Rye seeded for grain in Coastal bermudagrass. Agron. J. 59:467-472.

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The American Forage and Grassland Council and You

Warren C. Thompson, Immediate Past President

The American Forage and Grassland Council is on the move. It is out to prove to the American people that forage is a necessary and vital national resource. And that forage will become more vital and necessary in the future than even at the present to supply food for a growing population, to help conserve natural resources, and to provide more income to all who are concerned directly with this crop.

The Council has been in operation for over a quarter century. In this time, the key leadership has worked diligently to make it the spokesman for the forage industry. This has been a mean assignment for many reasons: 1) The leadership did not make a living organizing and putting together AFGC but rather they were building an industry in machinery and equipment, seed, fertilizer or were involved in research, teaching, education and AFGC rode side saddle. The time that was devoted to AFGC in effect was taken away from their prime interest and had to be considered an operation above and beyond the call of duty. 2) Location of the leadership made the operation almost impossible to function as a team effort. Just getting together is a mammoth problem especially when operating on a shoestring budget. 3) The diverse interest of each individual and sector puts additional strain on our organizational potential. With these handicaps we wonder how such a group even survived, let alone set up and run an organization that could well change the view and role of forage farming in North America.

How far and fast AFGC grows in service to the forage industry will depend on 1) the development of a team oriented package that will put together all the varying interests of industry, research and education and production into a living - acting - performing program. For instance, the seed trade has its American Farm Seed Trade Association and the Field Seed Institute, the Farm Machinery Manufacturers have its Farm and Industrial Equipment Institute and the fertilizer trade its Fertilizer Institute, the Potash Institute of North America, the Fertilizer Solutions Association, and The Sulphur Institute and others. Agronomy workers have their American Society of Agronomy. Animal Scientists have their American Society of Animal Science. The economics, engineers, entomologists, animal pathologists, sociologists, silo manufacturers, irrigation manufacturers, and others have their specific organization to listen and report to but who puts it all together? No one but a few dedicated extension, research and industry specialists, salesmen, and product managers who constantly keep their heads on the academic and industrial chopping block. If AFGC does nothing but establish communication between all of these groups, it will serve the country and the whole business of forage well. 2) The amount of funds that are available to the Council and the degree of autonomy that these funds are made available is a must. Time spent in getting funds is lost to production and action programs. It is not fair to the membership to spend time surviving when production is what members pay for. 3) The organization of supportive affiliate Councils at the operational level throughout the Country must get top priority. It makes no difference how big the program sounds and how well it reads, if not put to practice, it is of little

use to anyone. At the present we have seven affiliate Councils with eight more prospects this year. Recently an entire basic guideline draft was prepared and is available for all states wanting to organize. 4) The communication of research and education programs that are pin-pointed to assist farmers and ranchers to answer perplexing problems must be accelerated.

By 1980 there will be about 25 million more American mouths to feed than today. At the present demand rate, this will call for a 30% increase in meat and milk production. Well over 50% of the feed for the livestock to produce this meat and milk will come from forage. If it is economically feasible and the American farmer has the technical know-how to meet this need, it will be produced.

Let's take a quick look at forage as a business as it affects agriculture and the agri-business community. Of the one billion acres devoted to forages, 700 to 800 million acres are too steep, rocky, droughty, or otherwise unsuited at the present level of technology and economics, to produce crops other than forage. The remaining 200 to 300 million acres in forage could be planted to cultivated crops if these crops were sorely needed. The value of this crop as meat and milk is estimated at 8 billion dollars annually. Even though many areas are producing at only 20% to 25% of their known potential, the value of forages has been equated to the combined income from cotton, wheat, rice, soybeans, and tobacco and twice the value of the annual corn crop. Keep in mind also that about 80% of the corn produced in America is used for livestock feed.

Agri-business relies heavily on forage production for their existence. For instance, farmers spend about \$200 million annually on farm equipment for the production, harvesting, storing and feeding out of this crop. This represents an estimated 37% of the total farm machinery sales to this sector of the industry. Seed sales for the production of forages stands at \$250 or 28% of that industry's gross. Even though less than 2% of the 486 million acres of permanent pasture, 15% of the hay and cropland pastures and 18% of our improved pastures are fertilized annually, forages still receive 24% or \$200 million in fertilizer sales. If 30% of the permanent pasture acreage was fertilized at the present rate for those acres that are fertilized, this would mean an increase of 1,122,000 tons of N (Nitrogen), 1,650,000 tons of P_2O_5 (phosphate) and 1,550,000 tons of K_2O (potash). This amount is equal to less than 1/3 of our known potential for this crop, yet it would equal 50% of the total present fertilizer sales in America for all crops. Likewise, farmers spend about \$120 million annually for silos, \$40 million for pesticides and use 60% of the agricultural limestone for the production of this crop.

Why then since we have all of this market potential with the majority of the grasslands producing at only 20-25% of its known capacity and the knowledge that profits can be made with forages, why are farmers not beating the doors of industry, education and research to get these profits? The major reason has to be that up to now we have been able to meet all of the demands for meat and milk without adopting massive change. Do most farmers know the potential they really have in forages? Have we as leaders told them and have we provided the information to accomplish these potentials as systems of production and use?

To help unify teamwork at the research, education, industry, and production levels must be the role of AFGC in the 1970's. It is true that new technology is coming out almost daily, that new varieties are in use, that more and better fertilizer programs are being produced, that better machines are being developed, that livestock types that can make better use of forages are being produced, but to put all these elements together into a program that will give guidance and direction to all sectors leaves a lot to be desired.

AFGC can help by 1) providing a forum through which all sectors can be heard, 2) develop national programs and symposia that will cut across production disciplines, 3) publish on topics that are not available from other areas, 4) become an aggressive spokesman for the forage segment of Agriculture so that the expertise from the Council will be sought for counsel. We are making progress in all of these areas. However, to have the muscle necessary to accomplish our longtime goals, we must have more local interest and guidance, more funds to execute programs, and more programs with purpose.

To accomplish some of these broad and overwhelming objectives is going to take boldness. The base must be team oriented. The concern of one group is really the same as another's to feed a nation of people and help farmers, as well as industry make a profit for their efforts. It would be easy for industry to say "let's fund this group and let them get on with the job at hand". Funds without leadership is sheer folly to a group with such varied needs, location, and objectives. The Council must have both to succeed.

AFGC has established some long-range goals to better help serve all areas and interests of forages. Some of these are 1) to develop a budget and hire a full-time executive secretary and establish a national office to carry out the programs of the Council; 2) to develop regional Newsletters on subjects of prime interest; 3) develop educational materials such as slides, TV and radio tapes and publications; 4) develop symposia on matters of prime concern; 5) put together a library of forage information; 6) distribute information to the news media; and 7) help to develop proposals and add financial and leadership support to research and education on perplexing and predicted problems.

What is planned for the immediate future - this year, 1973?

1. A Research-Industry Conference. It will be held in Louisville, Kentucky, February 12-14. It will be held just prior to the National Farm Machinery Show.
2. A national symposium on Forage Fertilization in cooperation with TVA, ASA, and others.
3. The release of a comprehensive review of current grassland agriculture in America.
4. Publication of the quarterly "Grassland Progress".
5. Increase in emphasis to organize more state and regional Councils.
6. Secure more corporate support.

What can you do? If you are not a member, get to be a member. If you are not involved, get involved. AFGC needs you and I feel all of us need this spokesman to help us meet the demands for food for this nation and to better protect our resources for those who are to follow us. Together we can do it. Separately we will accomplish little.

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Fueling the Forage Revolution in the South

Del Deterling, Southwest Editor
The Progressive Farmer

Several months ago -- about the early part of March -- I was flying back to Dallas from a field trip in another part of the country. As we began to make our descent -- still some distance out from Dallas -- the wing of the aircraft dipped, affording the passengers on my side with a full-window view of green fields of wheat, oats, barley, and ryegrass. Off to the horizon could be seen the first traces of bermudagrass coming back to life after a brief winter's rest.

My companion -- seated next to the window, his bulky topcoat giving him away as a resident of one of the northern States -- peered intently out the window, shook his head wistfully, and exclaimed: "I just can't believe it is already so green. We're still snowed in where I live."

The thought struck me that this must indeed be a strange and envious sight for many who are not as fortunate as we are to live in the southern United States. How blessed we are that we have been given the opportunity to live and work in a part of the country where winters are of relatively short duration, where extremely cold temperatures and snow are a rarity, and where you can have green plant growth almost the year-round.

But for those of us in agriculture, this is more than a matter of comfort and aesthetics. It means that we have a year-round opportunity to harness the sun, the rain, and the land and use this energy to fuel plant growth.

For us, the miracle of the green leaf is a daily occurrence. Powered by sunlight, the green leaf -- through photosynthesis -- produces growth that nourishes all life.

And the South -- with ample rainfall, twice as many growing days as the rest of the U.S., and hundreds of millions of acres of under-utilized land -- can, through the green leaves of forage, become a land of profit, as well as beauty.

I need hardly spend much time reviewing for you the significance of forage to the U.S. and to the South. Forage, as Warren Thompson writes in the current issue of The Progressive Farmer, is the biggest and most significant agricultural enterprise of all, occupying some 1 billion acres of land in the U.S., and producing approximately \$8 billion in agricultural income annually. This is more than the combined value of the sales of cotton, soybeans, wheat, tobacco, and rice.

Forage is big business in the South, too. Forage, of course, is just so much cellulose, of little value until it is converted to animal protein -- meat or milk. True, you can obtain equal or better food value from extruded alfalfa, I am told, but most folks prefer to consume their protein in the form of a good, tasty steak or a glass of cold, nourishing milk.

Beef and dairy are the two largest producers of cash farm income in the South and Southwest, accounting for some \$5.7 billion in 1970. Assuming that roughly 60% of the value of beef and milk is represented by forage, we come up with a value for forage of approximately \$3-1/2 billion annually. It is a fair-sized company that we, in this room, work for -- producing roughly twice the annual sales of General Motors, the nation's number 1 industrial firm.

But this isn't where the story ends. This is really where it begins, because we've really just scratched the surface in what we can achieve with the fantastic potential we have to produce and convert forage into food products.

We have all the necessary resources -- three times as much energy from the sun as most northern States, according to Dr. Glenn Burton .. ample rainfall.. and hundreds of millions of acres of land either not being utilized at all or which have not been put to its highest use. We have all the ingredients to touch off a forage revolution in the South.

All the indicators point to the South and Southwest becoming the Beefland of the World during the decade of the 70's. The southern half of the country already has 40% of all the beef cattle, in the country -- approximately 36 million cows and calves. Industry and government experts have projected that U.S. beef cow numbers will have to increase 3% annually between 1970 and 1980 to supply the demands of consumers for beef.

That means the producers in the South and Southwest will have to add 5-1/2 million cows by 1980 to equal the projected growth. Actually, I think these estimates are overly conservative. They assume an equal rate of growth for all areas of the U.S. But in the 10-year period from 1960 to 1970, the South accounted for nearly half the increase in beef cattle.

With our natural advantages of climate and rainfall, and the progressive nature of our producers, there is no reason to assume other than that the South and Southwest will continue to show a proportionately greater percentage of the growth in beef numbers. By 1980, this area should be producing 60% or more of the nation's beef.

Forage will play a major role in this increase. Not only will there be an increase in numbers of cattle, but also a greater portion of the total pounds of beef will be produced on forage.

So, I don't think it is too far out of line to say that when we are talking about the forage industry in the South and Southwest, and its potential for growers over the next 8 to 10 years, that we are looking at an industry with potential value of \$6 to \$7 billion sales annually.

You know better than anyone, that to reach this potential, producers will have to put a premium on intensive forage management. They must treat forage as they would their best crop and manage it as they do their best crops.

They must manage it through the establishment and seeding of improved grasses that are especially adapted to their growing conditions and to their specific forage requirements. They will have to fertilize at rates heretofore considered out of the question -- perhaps up to 1,000 pounds of plant food per acre. They must control weeds, diseases, and other pests that reduce production.

And they must practice systematized grazing management and utilize precision harvest and storage systems.

Hand in hand with forage management improvement must come livestock management improvement to assure that the animal has the genetic and physical ability to utilize forages efficiently and convert them into milk and meat.

Can the job be done? I maintain that the answer to that question lies squarely at the door of those of us assembled here tonight, as well as our coworkers in the institutions and firms that we represent.

We dare not delude ourselves into thinking the job will be easy. The road is fraught with problems, obstacles, pitfalls, and frustrations that would deter us from reaching our goal. I would call your attention to some of these obstacles.

The art and science of forage technology must be improved. Forage production and utilization have lagged behind the progress that has been made with crops and animals.

1) First of all, we must establish goals and objectives. Producers must have a target to shoot at or they are likely to fire in all directions or be satisfied with something far less than their full potential.

What should our goals be? Dr. Burton has suggested that our long range potential -- this is, 100 years from now -- might be three tons of beef per acre. Considering the breakthroughs we have achieved in the past 25 years in grass breeding, livestock selection, and fertilizer technology, that does not seem to be out of the question.

But for the more immediate future, is it unrealistic to project that by 1980 we should be able to produce a half-ton of beef per acre -- that is, raise a 1,000-pound steer per acre in 12 months, largely on forage?

But then, these goals should not be set arbitrarily, but should be arrived at realistically by teams of experts in the fields of forage production and utilization.

2) Which brings me to my second point. It is absolutely essential to the success of this effort that we use an interdisciplinary approach to program planning and problem solving. We haven't the time, and we cannot afford the luxury, of having agronomists working in their little corner, isolated and insulated from the animal scientists, or vice versa. Everyone has to be in this together -- the plant breeder, the pasture and forage specialist, the animal breeder, the nutritionist, the disease and insect specialists, the

marketing economist -- all of those who are involved in any way in the chain from conception to consumption of the product.

In that connection, I particularly want to commend this group for providing the forum for representatives from these various disciplines to get together and explore all of those facets that have a bearing on forage production and utilization. Also it is encouraging to see an increasing number of publications coming out of the land grant universities which indicate that the information was derived through a team approach.

3) We must, in effect, think more and more in terms of forage-livestock systems -- systems which integrate soil types, moisture availability, temperature, forage species, fertilizer, various types and classes of livestock, marketing, and financing into a smooth and workable program that will turn out tender, lean beef or wholesome milk, and at the same time yield a fair return to the producer.

4) We may, in fact, have to begin from scratch to design totally new forage-livestock systems. With the new and exciting plant materials that are becoming available from throughout the world, we may be able to design "super forages" -- with many times the productive and nutritive potential of any forages now in use. This, in turn, may necessitate the development of "super strains of livestock" -- more efficient machines to harvest the forage and convert it to food protein.

5) Once we have developed these forage-livestock systems, those of us involved in the educational process must take these systems and sell them to the producer. We must be prepared to show the needs for these systems, demonstrate that they are workable, and prove that they can be profitable. We must emphasize the interrelationship between production and utilization; that as you change one, you also must be prepared to change the other. Every new input into the system must have a cost/benefit ratio assigned to it so that the producer can evaluate its profitability to his forage-livestock system.

6) To aid producers in carrying out these programs, someone needs to design simple, efficient systems of measuring quality and quantity of forages. I am referring to techniques or devices the producer can use to measure how much growing forage he has and what its nutritional value is -- information he has to have to make sound managerial decisions on stocking rates, leasing costs, requirements for supplemental feeding, etc.

7) We also need to establish more meaningful and workable standards and grades by which hay can be marketed so as to reflect its true feeding value.

8) With all these problems demanding answers, the agricultural industry must be even more diligent to schedule its finances and its industry manpower so they are used wisely and effectively. Time is too short, research funds already are tight and promise to be even more difficult to obtain as State and national legislators become ever more urban-oriented.

Harlow J. Hodgson, principal agronomist for Cooperative State Research

Service in Washington, recently cited statistics indicating that the State Agricultural Experiment Stations across the country have lost about 80 Science Man Years of research on forages in the last 5 years and about 150 Science Man Years on research on forage consuming livestock. This is an ominous trend ...one we are likely to see continued. We have to use every dollar wisely and effectively. It will take even closer coordination by organizations such as this one.

All of these things can be accomplished, I feel, if we are willing to set our sights high enough, roll up our sleeves, and go to work on them - together.

The Progressive Farmer proposes to cooperate as a full partner in this team effort.

Most of you probably have seen or heard about The Progressive Farmer's Forage Profit series which was initiated in the March 1972 issue. This marked the kick-off of a long-range editorial effort to call to the attention of producers in the South and Southwest the potentials they have with forage, and to help power a surging movement to utilize their resources to turn potentials into reality.

Briefly, our plans call for us to publish a minimum of one article per month featuring new and significant ideas, techniques, and programs relative to forage production, management, and utilization through livestock.

In addition to the major feature each month which will go to all 1.1 million readers in the 18-State area that PF serves, regional editors in the Southwest, Southeast, Mid-South, and Upper South will be developing articles aimed toward the specific requirements and opportunities in each State.

We want you -- individually and collectively -- to consider yourselves as members of an editorial advisory committee ... to feel free to come to our editors with ideas of how we can serve as a more effective arm of your educational efforts. Come to us, write or call us about your ideas of how we can help producers increase forage profits. Keep us informed of research or demonstrations in your State or elsewhere that you consider to be significant and which can be useful. Use The Progressive Farmer as one of the many tools available to help you to tell your story to farmers and ranchers.

But our efforts in support of greater forage profits will not be limited to the pages of The Progressive Farmer. You will be hearing of conferences sponsored by The Progressive Farmer, bringing together various segments of the forage and livestock industry, agribusiness, State and national leaders to discuss how we can give further impetus to the development of this great opportunity.

You will be seeing our editors on the programs of various organizations and conferences promoting greater forage profits.

We are going to do our utmost to help turn these opportunities for profit

through forage into realities. But we can't do it all by ourselves. It will take the cooperation and assistance of all who have a stake in improving the profit situation of farmers and ranchers in the Southwest and the South. You have a vital interest in the success of this effort. We welcome your joining hands with us to help make the Forage Boom the Profit Opportunity of the 1970's.

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Committee Reports: Pre-Conference Executive Committee Meeting
Tuesday, May 16, 1972

The Executive Committee meeting of SPFCIC was called to order at 4:45 P.M. by Chairman R. C. Buckner. Present were H. Lippke and M. Montgomery (S 45); R. Smith, P. Gibson, and C. Taliaferro (SFBG); O. Garrison, Administrative Advisor to SFBG; A. Spooner (SFPEWG); L. Allen and L. Rommann (SFEWG) and R. Buckner, J. McCroskey, D. Timothy, and Bob Leffel (SPFCIC).

Chairman Buckner announced that the Nominations Committee is I. Forbes, J. Burns, and A. Spooner (Chairman); and that the Resolutions Committee is W. Cope, N. Pratt, and H. Ellzey (Chairman). Chairman Buckner received a letter from Dean Barnhart, dated January 27, 1972, inviting SPFCIC to Lexington, Kentucky, in 1973. Also, he received a letter from Director Cralley, dated February 25, 1972, inviting SPFCIC to Fayetteville in 1973. Spooner of Arkansas moved to yield to Kentucky, and indicated that Arkansas will resubmit an invitation next year, for 1974. Motion carried.

Chairman Buckner indicated that the week of May 28, 1973, will be most satisfactory with Kentucky. Monday, May 28, will be a day of travel; Tuesday, May 29, Work Group sessions; Wednesday, May 30, general session, and Thursday, May 31, Tour, SPFCIC. Housing and Cafeteria will be available in dormitories. Timothy indicated that Valez Fortuno may be on sabbatic for the forthcoming year. The Committee agreed that if Velez Fortuno is unable to assume the chair, McCroskey will assume the chair. Rommann indicated that Warren Thompson of Kentucky extends an invitation to SPFCIC to visit farm operations in Lincoln County, Kentucky, Tuesday afternoon of next year's schedule.

Dr. O. B. Garrison commented on the provision for cooperative regional research publications by Work Groups. There is no precedent for doing this type of publication, to his knowledge, but it is possible. Such a publication should give appropriate credit to States and Region, and may be processed and published by a State, with all cooperating States purchasing a predetermined number of copies. Dr. Garrison indicated that South Carolina is willing to be the vehicle if there is need for such a publication.. Possible publications on tall fescue and on white clover were suggested.

The 1973 SPFCIC program will be discussed at Executive Committee meeting immediately following the Banquet.

The meeting was adjourned at 5:42 P.M.

SPFCIC General Business Meeting
Wednesday, May 17, 1972

The general business meeting of SPFCIC was called to order at 5:15 P.M. by Chairman R. Buckner. The report of the Forage Evaluation Committee was given by J. Moore, and is appended herein. The report was accepted by consent. The Nominations Committee Report, presented by A. Spooner, nominated N. Pratt as Chairman Elect-Elect SPFCIC. A motion to close nominations and to elect Pratt by acclamation carried unanimously. The Report of the Resolutions Committee, appended herein, is to be given during the Banquet tonight.

Chairman Buckner announced that an invitation from Dean Barnhart to SPFCIC to hold the 1973 meeting at Lexington, Kentucky, had been accepted by the Executive Committee. The 1973 meeting schedule is work sessions on Tuesday, May 29, and general session and tour of SPFCIC on Wednesday, May 30, and Thursday, May 31, respectively. The Executive Committee meeting will be held tonight immediately after the Banquet, in the Red Room of Clemson House.

The meeting was adjourned at 5:26 P.M.

Report of Forage Evaluation Committee, SPFCIC
Presented by John E. Moore, University of Florida

The S-45 Regional Project Technical Committee acting as the Forage Evaluation Committee of SPFCIC presents the following report in order to bring before the Conference certain recent developments and considerations which are pertinent to the problems involved in routine laboratory evaluation of forage quality.

1. Excellent progress is being made in the current regional project. Several States have completed feeding and digestion trials on a variety of southern forages. Voluntary intake, rate of gain and nutrient digestibility data are being taken as measures of forage quality. A wide variety of laboratory procedures are being carried out on samples of the forages which have been fed. At this point, it is too early to draw conclusions concerning the validity of the various chemical techniques. The feeding trials will be continuing for at least two more years.
2. We continue to recommend the in vitro rumen fermentation procedure as the method of choice for screening large numbers of samples. Some information from the S 45 project emphasizes the point that interpretation of in vitro data be done with care. Some discrepancies do exist when forages of different species are compared, but within a narrow range, in vitro differences are closely related to differences in quality as determined from feeding tests.

3. We are pleased to report that the in vitro tests are being used at several stations in selecting lines for increase with the purpose of providing enough forage for feeding tests. These include millet and bermuda at Tifton, Klein and buffel at Texas, Sericea at Auburn, bermuda at Oklahoma, fescue at Tennessee, and digitgrass at Florida. It will be of great interest to learn how closely the in vivo digestibility data to be obtained on these selections will agree with the in vitro values on which the selections were based.
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Report of the Resolutions Committee, 1972

WHEREAS, the membership of the 29th annual Southern Pasture and Forage Crop Improvement Conference has enjoyed the enlightening benefits from its participation at the Conference, and

WHEREAS, such benefits could not have been without the friendly, warm, hospitable and concerted efforts of the staff and administration of Clemson University;

BE IT RESOLVED:

That this 29th Conference express the appreciation of its membership to the staff and administration of Clemson University for the warm, friendly, and genteel welcome extended to it and the use of the superior facilities provided during the meeting in Clemson and the Simpson Experiment Station;

That Clemson University and its personnel are to be commended for their awareness of the agricultural problems of today and their planning for tomorrow, and for their leadership and vision in attacking and solving the problems in improvement, management, and utilization of forage crops as we move toward the 21st Century;

That special recognition is extended to Dr. O. B. Garrison, Director of the Experiment Station, Dr. Luther P. Anderson, Head, Department of Agronomy and Soils, Dr. R. F. Wheeler, Head, Department of Animal Science, Dr. Willis King, Head, Department of Dairy Science, and all individuals serving on the Local Arrangements Committee for making our stay at Clemson so pleasant;

That special recognition is due and extended to Chairman Robert C. Buckner, Past Chairman and Program Chairman David H. Timothy, and to our esteemed, faithful, capable and personable Permanent Secretary, Robert C. Leffel.

THEREFORE,

We move that this resolution be adopted by unanimous acclamation and recorded in the Minutes; and further, that a copy of this resolution be sent to Robert C. Edwards, President, Clemson University.

H. D. Ellzey, Chairman
Will Cope
Neal Pratt

Post Conference Executive Committee Meeting
Wednesday, May 17, 1972

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Current Officers of Work Groups and Conference are as Follows:

	<u>S 45</u>	<u>SFBG</u>	<u>SFPEWG</u>	<u>SFEWG</u>	<u>SPFCIC</u>
A. Adv.	C. Little	O. Garrison		F. Ellmore	
P.P. Chr.					D. Timothy
P. Chr.	<u>M. Montgomery</u>	<u>R. Smith</u> ^{1/}	<u>G. Spain</u>	<u>J. Johnson</u>	<u>J. Velez Fortuno</u>
Chr.	<u>H. Lippke</u>	<u>P. Gibson</u>	<u>R. Brown</u> ^{1/}	<u>L. Rommann</u>	<u>R. Buckner</u>
Chr. E.	<u>J. C. Burns</u>		<u>A. Spooner</u>	<u>L. Allen</u> ^{1/}	<u>J. McCroskey</u> ^{1/}
Chr.E.E.					<u>N. Pratt</u>
Secretary	<u>J. C. Burns</u> ^{1/}	C. Berry	J. Reynolds	W. Thompson	<u>R. Leffel</u>
Directors	J. Arroyo-				
	Aquila				
	K. M. Barth				
Others		W. Knight ^{2/}			
		C. Taliaferro ^{3/}			

^{1/} Program Chairmen, 1973

^{2/} National Foundation Seed Project Representative, 1972-74

^{3/} National Foundation Seed Project Representative, 1972-76

Members of SPFCIC Executive Committee are underlined in above table. Chairmen (or their designated representative) and Past Chairmen of Interest Groups (1 vote per Interest Group) and officers of SPFCIC constitute the Executive Committee of SPFCIC.

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Pratt mentioned the possible visits to farm operations in Lincoln County at next year's meeting in Kentucky — it was not clear as to how these visits can be scheduled for Work Groups or SPFCIC. Timothy commented that not all workers attend both Work Groups and SPFCIC meetings and that SPFCIC should present a complete program. Gibson suggested a coverage of the history of tall fescue in next year's program, followed by problems, research needs, utilization, aspects of legume associates, etc. Buckner indicated that the program should be planned to be of interest to all Work Groups. Pratt suggested inclusion of white and red clovers as part of the fescue story. Lippke indicated that management of tall fescue should be included.

Buckner indicated the need in next year's program for an extension specialist to cover the education of farmers on the use of tall fescue in forage systems. The consensus was that we have at least a half dozen extension specialists within the region that are especially well qualified to present this aspect. Pratt raised the question as to whether there will be sufficient time on next year's program to consider other cool-season perennial grasses. It was noted that SFPEWG will discuss year-round management systems at next year's work session.

Buckner indicated satisfaction with the foregoing comments and suggestions and will proceed with the planning of next year's program. Leffel reported a balance of funds of \$325.59. The meeting was adjourned at 10:15 P.M.

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SOUTHERN FORAGE BREEDERS WORK GROUP

May 16, 1972

Rex L. Smith, Presiding

Potential for Development of High Quality, Winterhardy
Bermudagrass Varieties

Glenn W. Burton

USDA, ARS, PSRD, Tifton, Georgia

I believe the potential for developing high quality, winter hardy bermudagrass varieties is excellent. We know that both characters are heritable, we have parents superior (in one or the other of these characters) to varieties in current use, and we have no reason to believe that these important characters are incompatible. Midland bermudagrass (the best of 66 hybrids we made between Coastal and a more winter hardy bermuda from Indiana in 1942) proved that a good hybrid, more winter hardy than Coastal, could be bred. Coastcross-1 (the best of 385 sterile F_1 hybrids between Coastal and Kenya 56 produced in 1959) has shown that quality can be improved by hybridizing the right parents and using the NBDMD or IVDMD techniques to isolate the hybrids with the best quality. Unfortunately, Coastcross-1 lacks the winter hardiness required for most of the South.

There are many breeding problems but they are not insurmountable. Our two best quality bermudagrass parents, K 61 and K 393, lack winter hardiness and are short day types that may not flower at the right time to make hybrids. K 393 flowered for the first time in 1971. K 393 has a high HCN content; the other parents have none. K 61 and K 393 have no rhizomes and the non-rhizomatous character may be dominant in some crosses. The winter hardy parents I 592 and I 600 that I collected in Berlin and the Alps of North Italy in 1966 are low yielding common types and I 600 is often male sterile. The parents have such a low compatibility that 100 to several thousand florets must be pollinated to produce a single viable seed. The F_1 hybrids are sterile making common plant breeding procedures for obtaining character recombination impossible. Mild winters make winter hardiness screening uncertain. Finally the new winter hardy, high quality bermudagrass variety should be comparable to Coastal bermuda in all other traits such as pest resistance, yield potential, and drought tolerance, a very large order.

Fortunately commercial propagation of bermudagrass by vegetative means is highly practicable. Thus only one superior plant that meets the requirements need be found. Sterility in such a plant will be desirable in that it will greatly reduce the weed potential of the new variety.

The first set of F_1 hybrids between K 61 and the winter hardy European bermudas (I 592 and I 600) were subjected to several consecutive days with minimum temperatures of -4° F without snow cover at the Mountain Experiment

Station at Blairsville, Georgia. Survivors compared with parents and checks in a 9 x 9 lattice square test (5 reps) planted in April, 1971 at Tifton varied greatly in all characters studied. Six of the best hybrids yielded as well as Coastal and gave IVDMD values equal to Coastcross-1. These hybrids started off slower in the spring of 1972 than Coastal. More testing will be required before their true worth is assessed.

Nearly 2000 F₁ hybrids are currently being evaluated at Blairsville and over 8000 more will be space planted there in late May, 1972. Our experience to date suggests that these 10,000 F₁ hybrids should contain the desired plant.

Our success with mutation breeding of turf bermudagrasses caused us to try this method as a means of increasing the winter hardiness of Coastcross-1. On June 21, 1971, some 400,000 active green stems of Coastcross-1 were exposed to 7 kR at Oak Ridge, Tenn. On the same day they were broadcast and disked into prepared soil at Blairsville. By the end of the season, some 25 chlorophyll deficient stem sectors were found in plants from irradiated stems. On May 5, 1972, we found 4 surviving shoots of Coastcross-1 in the field planted to irradiated stems. There were no surviving plants in the field planted to non-irradiated material. A minimum temperature of -2° F was recorded at Blairsville this past winter. Further testing will be required to insure that the surviving shoots are truly more winter hardy and not escapes.

I believe an outstanding winterhardy high quality bermudagrass hybrid can be produced. It will require much work and a team approach. For our program, key people in the most important screening and testing program will be Jim Dobson at the Mountain Experiment Station at Blairsville, Warren Monson and the forage research team that includes the animal scientists at Tifton. Will it be worth it? Average daily gains produced by steers grazing replicated pastures of Pensacola bahia, Coastal and Coastcross-1 bermudagrass for the past 4 years at Tifton have been .95, 1.07 and 1.50 pounds. A winter hardy bermudagrass with the performance of Coastal and the quality of Coastcross-1 could be worth millions to the cattle industry of the South. Yes, I believe it will be worth all we have to put into it and then some.

Breeding Improved Varieties of Grasses Belonging to the Genus Panicum

Ethan C. Holt
Texas A&M University

The emphasis in this discussion will be on the Panicum coloratum complex. We are doing some work with P. antidotale but the species has limited application even in Texas. P. coloratum was first introduced in 1942 and again in 1948 but the material was not promising. New materials were obtained in the early 1950's that were fine stemmed and leafy, but because of the seed shattering problem, not much was done with them. The Soil Conservation Service went so far as to make a series of plantings varying in size from 2 acres to 10 acres about 1956 but nothing further came of this immediately.

The major problem with P. coloratum, identified as such since the first observations and plantings, is that of severe seed shattering. Our first efforts in breeding were to observe populations for variability in seed shattering. We had some problem in separating seed shattering from differences in seed maturity, but concluded that we had no real variation in original collections for seed retention.

Cytological studies and progeny variability for agronomic characteristics verify sexual reproduction. Limited embryo sac abnormality in glaucous, robust types along with absence of crossing with green types suggested irregularities in reproduction. Our failure to pursue this aspect is subject to criticism in view of our emphasis on apomictic breeding in buffelgrass. Certainly if potential for similar approaches exists in P. coloratum, it needs to be explored and exploited. Later work with another plant introduction indicated segregation for the glaucous characteristics, suggesting natural crossing between coloratum and makarikaninse types and the likelihood that makarikaninse is also sexual.

Since the work with seed development aspects indicated that extensive research would be required for satisfactory improvement, we decided to join with SCS in the release of the best available material while continuing to work toward improved seed production. Kleingrass 75 was thus released and is making a major contribution, being adapted from East Texas westward to <20" and the Lower Rio Grande Valley to at least the central Panhandle area. Not only is its adaptation superior but also its quality and carrying capacity are superior especially in the drier areas of the state.

We have had several objectives in the breeding program and one of the problems has been the addition of objectives or of breeding materials after work had been initiated on earlier objectives and/or materials. This is the case with seed retention, forage quality and now with seed size.

Spaced plant populations indicated a wide range in growth habit in P. coloratum and the potential to stabilize populations differing in growth habit. This was accomplished while looking for differences in seed production characteristics. We used the polycross or maternal line approach, with recurrent selection when considered desirable.

We were surprised at the limited progress in the second cycle of selection with most types. Apparently we had exploited most of the genetic variation in the first cycle of selection. Later heritability estimates based on parent-progeny studies confirmed this conclusion. Since the ranges were not affected within the types it would seem that further progress, especially in the erect and decumbent types, should be possible. It seems likely that the extreme types were not considered desirable and thus were avoided in re-selections, and this may account for the limited changes especially in the erect and decumbent categories.

A detailed study of seed production characteristics failed to identify differences in seed retention in P. coloratum. However, the study did

establish heritable differences in panicle size (fertile florets per panicle) and fertility (percent seed set) and with differences in panicle number per plant. Thus it seemed likely that seed production could be increased which should result in a greater amount of seed at any point in time in the maturity cycle even though seed retention did not exist. This approach was used and resulted in significant increases in harvested seed (40 to 50 percent).

While all initial work had failed to identify seed retention types, a rather detailed observation of some 20,000 plants over a two-year period identified one plant on which seed were retained until the inflorescence was mature and several plants on which a few spikelets were retained. These plants were combined in a synthetic which shows improvement in seed production over unselected material. Progeny test would indicate that at least one of the parent clones should be eliminated at the risk of restricting the gene base for other characteristics.

While attempting to identify and characterize some marker genes or characteristics, we did a considerable amount of forced selfing in P. coloratum. Self progeny from two lines show a rather high degree of spikelet retention at least until inflorescence maturity. Apparently the characteristic is masked in some way in more heterozygous material. P. coloratum loses vigor with selfing and we are now in the process of determining how to use the most recent material. We likely do not have a sufficiently broad gene base either within or among the few lines involved to restore vegetative vigor with intercrossing. The main question is whether we can retain or recover seed retention with outcrossing to restore vigor.

We have noted that selection pressure only for seed production results in reduced plant height and apparently plant vigor. One of the synthetics based on panicle size and fertility has good vigor while two of these synthetics seem to be less vigorous. We are now in the process of outcrossing to vigorous clones in an attempt to increase vegetative vigor while retaining good seed production.

Two synthetic varieties have been developed that produce 25 to 45% more seed than Kleingrass 75 and 12 to 30% more forage. Thus, we have been able to increase seed production while retaining satisfactory vigor, and it seems unlikely that both can be increased at least 40 to 50% over Kleingrass 75.

Recently, we have added breeding for improved quality to the program. Kleingrass quality (dry matter digestibility) is probably above average for tropical perennials but preliminary investigations indicated potential for further improvement as well as the possibility of using it to identify factors with causal roles in quality. The digestibility of Kleingrass forage is on a par with Coastcross-1. Our first approach has been to screen individual parent and progeny plants in experimental synthetic varieties developed for seed production, on the basis that we should already have these characteristics somewhat stabilized in the population. At the same time, since no selection pressure has been exerted on quality, we should have genetic variability for the characteristic within populations selected for other

characteristics. This would save time otherwise required for crossing and progeny testing followed by combining desired lines and evaluation of the synthetic. Even then a second cycle of crosses and progeny evaluation might be necessary to obtain the desired combination of seed production, vigor and forage quality.

Evidence to date indicates adequate variability for significant advancement in forage quality. A range of more than 15 percentage units was found within a progeny population of >1000 plants from parent clones previously selected for other characteristics. More refined evaluations conducted in 1971 have just been completed and the data not yet evaluated. Screening of all existing material in P. coloratum has not yet been undertaken.

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Status and Potential of Orchardgrass Improvement

L. H. Taylor
Virginia Polytechnic Institute

Historical Background

Use of orchardgrass in North America began in Colonial times. The 1948 Yearbook of Agriculture states that "orchardgrass was first cultivated in Virginia" and mentions the date as 1760. Wilson and Myers say that "It is probable that the name "orchard grass" was given to the grass because the seed for the first planting in Kentucky - from which seed was raised commercially - was collected in an orchard in Virginia."

I will sketch only briefly, by periods, progress in orchardgrass improvement work.

Before 1920 - Breeding work began in Great Britain, Scandinavian Countries and Canada

1920's - First improvement work in the U.S.

1930's - Work in a number of states began. The 1936 Yearbook of Agriculture speaks of work needed to advance the field of breeding grasses despite lack of knowledge of proper technique and inherent difficulties in handling the floral parts. The 1937 Yearbook of Agriculture lists programs of orchardgrass breeding in eight states - the two programs in the South, in Virginia and Kentucky, being the earliest work reported. In 1936 the Pasture Research Laboratory was established at Penn State.

1940's - Expansion of breeding programs in late 40's. Influence of corn breeding techniques.

1950's - More workers trained in forage crop breeding. Release of a number of orchardgrass varieties. New programs inaugurated in the South.

1960's - More varieties. Orchardgrass breeding by commercial plant breeders began in significant amounts.

1970's - Will consider as we look at the present.

Present Situation

A. Varieties

Based on the Report of Seed Certification Agencies in 1971 the four leading varieties in the U.S. are:

- 1) Potomac - USDA 1954 3 cycles of Mass Sel. from 1945 Nursery.
- 2) Latar - Washington & Idaho 1957 Mass Sel. of P.I. from Russia
- 3) Boone - Kentucky 1961 Increase of 400 pl. sel. from 25 naturalized strains.
- 4) Sterling - Iowa 1960 5-clone synthetic.

These and other named varieties are still not widely grown.

About 3/4 of the orchardgrass acreage is not seeded to named varieties.

B. Breeding Programs

- 1) Northeast
- 2) North Central
- 3) West
- 4) South

Improvement programs formerly or at present in Kentucky, Virginia, North Carolina, South Carolina, Arkansas, Tennessee and Mississippi. Less emphasis and a lower level of effort in recent years.

5) U.S.D.A.

6) Private breeding programs. Plant Protection Act.

C. Why There is Less Effort by State and Federal Programs

- 1) Competition for limited funds and SMYS
- 2) Lower priority for forage breeding work
- 3) Feeling that less State and Federal effort needed because
- 4) Commercial companies will produce our new orchardgrass varieties

Potential

A. Of the Species

Orchardgrass will continue to be an important forage species.

Acreage should remain stable and may increase. A greater portion of this acreage will be seeded to improved named varieties.

B. Of Orchardgrass Breeding Programs

Some State and USDA orchardgrass breeding programs will be continued. They are needed to provide basic information on which real improvement must be based. There must be a practical and better way than we now know to develop improved strains and get them into use on farms. It is not yet resolved as to whether government or private programs will provide the orchardgrass strains that can best serve our needs.

References Cited or Used

- Wilson, H. K. and Myers, W. M. Field Crop Production. 1954. J. B. Lippincott Co.
- 1936 Yearbook of Agriculture
- 1937 Yearbook of Agriculture
- 1948 Yearbook of Agriculture "Grass."
- Report of Acres Approved for Certification in 1971 by Seed Certification Agencies. Compiled by C. S. Garrison and Nancy Compton.
- Hanson, A. A. Grass Varieties in the United States. 1965. Agricultural Handbook No. 170.
- 1969 Trends in Forage Crops Varieties. Compiled by John R. Paulling, Federal Extension Service, U.S.D.A.

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Problems and Progress in Breeding White Clover

Pryce B. Gibson

USDA, ARS, PSRD, Clemson South Carolina

Historically white clover, Trifolium repens L., man and domesticated cattle have close connections. From the beginning of this association cattle have scattered white clover seed which remain viable as they pass through the digestive system. Later, man using "hay loft" sweepings as forage seed spread the species. The grazing of the animals combined with some management by man have exerted selection pressures. Consequently, the evolution and spread of white clover are closely associated with the domestication of cattle and the movements of man.

The dual value of white clover as a quality forage and as a supplier of nitrogen for an associated grass was recognized some time before the symbiotic relationship of legumes and Rhizobium bacteria was explained. Apparently, the dual value of the crop and the ways of mother nature that favor scattering of the seed, account for white clover becoming the most important pasture legume in the moist areas of the temperate zones of the world.

Although the low cost of nitrogen fertilizer in recent years aided in some countries by government subsidies has challenged white clover's importance as a source of nitrogen for the grass, its importance as a forage of unsurpassed quality remains unchallenged. Work in Great Britain has shown a positive beneficial response in terms of feed intake and live weight gain from the addition of clover to grass in the diets of cattle. The British conclude that the very marked response obtained by the addition of a legume to the feed indicates the need for caution in restricting animal diets. (W. Williams, "White Clover in British Agriculture" in WHITE CLOVER RESEARCH, Occasional Symposium No. 6., edited by J. Lowe. British Grassland Society 1970). Apparently, the association of clover, cow, and man will continue for some time.

The characteristics of white clover make it well adapted to genetical studies

and to development of improved varieties by applying breeding techniques developed for cross-pollinated small seeded perennial forages. Variation is abundant in the species and this variation has been utilized to some extent in developing varieties for specific uses e.g. irrigated pastures and early growth. In the United States we have attempted to develop an improved variety for general use within a rather extensive area. The requirements for developing, and maintaining the variety and for producing seed of the variety more or less dictate this approach.

Interspecific hybridization provides variation beyond that in the species. This variation provides the possibility of creating white clovers with entirely new characteristics. For example, rhizomes, woody roots, resistance to viruses.

Problems

My assignment is to discuss problems and progress in white clover breeding. Considering the high quality of white clover forage and the wide distribution of the species one might erroneously conclude that problems would be minor. Unfortunately, breeders of white clover are confronted with unique problems largely man-made. I say this because the breeder can acquaint himself with all there is to know about the genetics, cytology, pathology, and physiology of the crop but unless he knows how varieties are to be evaluated, used and managed how can he clearly define his objectives?

I want to mention some of the man-made variation that confronts the white clover breeder.

Variable demands on crop or uncertainty of use and management:

1. Used as a perennial or a reseeding annual.
2. Used alone and in a clover-grass mixture.
3. Planted with different grasses -- Dallis, Tall fescue, Bermuda, etc.
4. Overgrazed, undergrazed, rotationally grazed, grazed continuously, stockpiled.
5. Variable fertility - No fertilizer, minerals only, minerals + N, N only.
6. Variable soil acidity - lime often needed.
7. Fertilizer applied - annually, longer intervals, spring, fall.
8. Planted on hillsides, bottoms, good soil, etc.
9. Fall and spring plantings -- too early, too late.
10. Seed inoculated, not inoculated.
11. Seed broadcast or drilled on thoroughly prepared seedbeds, scarified grass sod, no renovation.

Occasionally mother nature provides conditions (so called clover years) so that white clover may do well under one or even a combination of several adverse conditions. Too often this success under adverse conditions is used as justification for wrong cultural practices and even as the basis for recommendations by an "Agronomist."

Variable evaluation techniques:

1. Variable number of harvests.
2. Variable height of harvests.
3. How yield is determined varies - rotary mower, cutter bar + rakes, estimates.
4. Animal evaluation - steers, dairy, young, mature.
5. Grown alone or with grass.
6. Time of harvest - calendar, height of clover, height of grass.
7. Stand measurement - stolon counts, ground cover, estimate.
8. Variation in seed quality may result in variable stands then yields from thin stands may be compared with yields from thick stands.

I believe the items listed are sufficient to emphasize the point that breeding objectives are more difficult to define clearly than with annual cash crops.

Although I have not exhausted the list of problems, I believe those I have mentioned are by far the most important.

Progress in Breeding

In considering the improvement of white clover the minus and plus characteristics of the species that determine its contribution to pastures must be recognized and evaluated.

Plus characteristics:

1. Probably the most nutritious pasture plant we have.
2. Retains high quality throughout the productive season.
3. Rich in minerals, trace elements and amino acids.
4. Contributes nitrogen to the soil and to the associated grass.
5. Environmental - Slow release of N to associated grass does not create a problem of high nitrogen levels in inland waters.

Minus characteristics:

1. Since only the leaves are harvested yields are relatively low.
2. Unreliability of stands - lack of persistence.
3. Requires continuous and intelligent management of both pasture and animals.

A logical approach to breeding white clover is to make improvements in the minus characteristics. Breeders can and are making progress in numbers 1 and 2. Progress in number 3 requires simple understandable recommendations, and this progress must be made by or in cooperation with other disciplines. Also, number 3 is concerned with several of the items I have mentioned in discussing problems. The opportunity for progress in number 3 is great and I hope progress will be rapid. Such progress will make advancement in purely plant breeding much easier.

In our breeding program we have assumed that the only use of white clover of sufficient importance to justify developing a variety for this use is the clover component of a mixture of clover and grass. Accordingly, we believe variety and strain evaluations should be made by growing the clover with a grass.

The low yield of white clover is not as important as it may sound. We believe the total yield of forage (i.e. clover + grass) and the distribution of production throughout the growing season is much more important.

In respect to yield, we are interested in increasing the percentage of the plant consumed by the animal and also in maintaining the quality. If the stems (stolons) of white clover were included in yields as are stems of alfalfa and red clover, yields would be more comparable.

Since only the leaves of white clover normally are harvested by grazing much of the food in the stems is lost. Some of the food is translocated to new leaves, but most of the stem eventually makes its contribution by enriching the soil and thereby stimulating growth of the grass. The weight of a unit length of stolon may exceed the weight of the attached leaves. Thus, by shortening the internode we increase the percentage of the photosynthate consumed by grazing. Shortening the internode also places new leaves closer to the established root system and may improve persistence.

Length of internodes varies with genotype, age of plant and environment. Although progress toward short internodes has been made by selecting within the species, interspecific hybridization offers possibilities for faster and greater change. Internodes of T. uniflorum are much shorter than internodes of white clover. We have eight hybrids of the two species. These hybrids are intermediate to the parents and are vigorous plants. We are optimistic about their use in developing better varieties of white clover.

Besides being a source of short internodes, T. uniflorum may be a source of woodier and deeper roots, tolerance to some viruses and a source of larger seed. Larger seed in turn may result in more seedling vigor.

Individually or in total these characteristics from T. uniflorum should contribute to improving the persistence of white clover. Thus, hybridization with T. uniflorum may lead to improvement in the minus characteristics I have numbered 1 and 2.

Plants of the diploid species T. occidentale are small stoloniferous perennials very similar to white clover. Along the seacoast of England, France and Spain, plants of this species persist on soil too sandy and droughty for white clover. Also, the plants are tolerant to some of the clover viruses. Thus, this species offers possibilities for improving white clover.

Although hybrids between white clover and diploid T. occidentale are obtainable hybrids with the colchicine induced autotetraploid are preferred because hybrids are easier to obtain and the resulting hybrids are more vigorous and more fertile. The hybrids are vigorous dark green plants and have

the potential of contributing to improved persistence of white clover.

We have obtained and are especially optimistic about the potential use of a hybrid between T. uniflorum and T. occidentale (4x). We have succeeded in making this hybrid only once. This hybrid produces about 80% viable pollen and is self-compatible. It is light green in color and generally intermediate to its parents. Our interest in the hybrid is its cross compatibility with several clones of white clover. Hybrids are easier to make and we have succeeded in hybridizing more white clover clones than in direct cross with T. uniflorum.

Another interesting characteristic of this uniflorum - occidentale hybrid is that backcrosses of it to T. uniflorum also hybridize with several clones of white clover. We like these backcrosses because their ratio of uniflorum to occidentale germplasm produces exceptionally promising hybrids with white clover. Some of these hybrids have the characteristics we want -- short internodes, strong deep roots, and profuse branching of the stems. Our problem is to stabilize these characteristics in a variety.

I hope you will observe our hybrid plants while you are in Clemson. We have plants in the greenhouse and in small field plots. A few of you may have the opportunity to observe some of the same hybrids in the field at Raleigh, N.C., Tifton, Ga., and State College, Miss. These evaluations are being made in cooperation with Dr. W. A. Cope, Dr. Ian Forbes, and Dr. W. E. Knight, respectively.

Besides species hybridization I should mention other progress in breeding white clover. In recent years, the variety Tillman released cooperatively by the S.C. Agr. Exp. Station and USDA, the variety 'Regal' released by the Ala. AES and La S-1 released by the La. AES, were developed by utilizing natural variation in the species. This year we released SC-1 Germplasm, the seed increase from 145 clones selected for tolerance to root-knot nematodes. SC-1 should be excellent source material for breeding programs.

Progress in other disciplines is contributing to progress in white clover improvement. Dr. C. C. Chen has made valuable contributions in cytogenetics and embryology of white clover, related species and species hybrids. Dr. O. W. Barnett has made considerable progress in clarifying the virus problems of white clover. I encourage those interested in these disciplines, to visit with Dr. Chen and Dr. Barnett.

Alfalfa in the Southern States

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Beef cattle numbers in the Southeast have increased steadily and markedly during the last 20 years. In 1970 the inventory of beef cattle and calves totalled 272 percent of the 1950 inventory in 12 southeastern States. By comparison, the inventory in the 48 contiguous States of the Nation in 1970 was about 214 percent of the 1950 number. Slightly less than 17% of the

national total of beef cows were located in the Southeast in 1950. By 1970 the 12-State area included almost 25% of all beef cows in the USA. By 1980 this area is expected to contain 33% of all beef cows in the country. A substantial boost in beef cow numbers throughout the Southeast is expected to accompany an anticipated increase in the productivity of existing pastures as a result of improving fertilization, pasture species, and forage utilization practices.

During the period 1950-1970, dairy cattle numbers in the 48 States declined steadily, from about 35.5 million to 21.1 million head. In the Southeast, by contrast, the dairy cattle inventory increased from about 7.0 million head in 1950 to nearly 7.2 million in 1955, but declined steadily and rapidly thereafter to a total of only 3.5 million in 1970. From about 20% of the national dairy cow inventory in 1950, the milk cows in the Southeast in 1970 represented only about 17 percent of the national total. Dairy cow numbers in each southeastern State are expected to change at a much slower rate, however, during the 1970's than during the 1960's.

There is an apparent need for more and better forages to support an expanding livestock industry in the South. Alfalfa, one of our most productive and nutritious forage plants, is grown throughout the temperate zone of the world. Can alfalfa become a more important crop in the South in the future than it is today? In this paper I attempt to define the present status and potential of alfalfa in the South.

Distribution

The present distribution of alfalfa grown for hay in the continental USA is shown in Fig. 1. Alfalfa is an important crop for the country as a whole but little is being grown in the humid South. More alfalfa was being grown in the South before the advent of the eastern alfalfa weevil in the middle 1950's. The acreage in North Carolina was reduced from approximately 100 thousand to 8 thousand acres in a short time. Present acreage is only 12 thousand acres. In Tennessee acreage dropped from 250 thousand acres to a current acreage of less than 60 thousand. Acreage has never been large in South Carolina, Georgia, Alabama, Mississippi, and Florida. The alfalfa weevil has not been a serious pest in Louisiana, Arkansas, Texas, and Oklahoma, but it is now becoming serious in these States. The alfalfa weevil is but one of several problems associated with alfalfa production in the South. It is a problem that must be resolved, however, before acreages will increase in this area.

A considerable acreage of alfalfa is grown in Oklahoma and Texas but much of this acreage is outside the humid South. Some alfalfa is grown in the fertile alluvial valleys of the Arkansas, Red, and Mississippi Rivers in Arkansas, Louisiana, Tennessee, and Mississippi. Most of the remaining acreage is in the Ultisols of Tennessee, North Carolina, and the northern one-third of Alabama, Georgia, and South Carolina. To some degree this distribution encompasses the southern soils with the higher pH values. Many of the Ultisols, especially in the lower South, are deficient in lime, phosphorus,

and potassium. Soil deficiencies are less in the Red, Arkansas, and Mississippi River Valleys, but on these soils there is greater competition from crops other than forages.

Varieties

From communications with forage specialists in the Southern States it was determined that the following alfalfa varieties are being grown in the South.

Oklahoma: Oklahoma Common (50%), Cody (30%), Buffalo (10%), and Kanza, Dawson and others (10%).

Florida: Florida 66, African, Hairy Peruvian, and Sonora.

South Carolina: Cherokee (most of the acreage), Team, Weevlchek, and Oklahoma Common.

Arkansas: (listed in order of importance) Buffalo, Vernal, Delta, Cody, Lahontan, and Oklahoma Common.

Tennessee: Buffalo (most of the acreage), Cody, Vernal, and Williamsburg.

Louisiana: Buffalo.

Alabama: Kansas Common, Oklahoma Common, and Delta.

North Carolina: Cherokee (most of acreage), Weevlchek, Team, and Williamsburg.

A brief description of these varieties is as follows:

Oklahoma and Kansas Commons: These varieties are not recognized by certifying agencies and are identified only by the name of the State in which they were produced.

Buffalo: Developed by Kansas Agricultural Experiment Station and U.S. Dept. of Agriculture. Bacterial wilt resistant selection out of Kansas Common.

Cody: Released by Kansas Agricultural Experiment Station and U.S. Dept. of Agriculture. Resistant to spotted alfalfa aphid. Resistant to bacterial wilt. Moderately winterhardy. Selection out of Buffalo.

Kanza: Developed by Kansas State University and U.S. Dept. of Agriculture. Winterhardiness similar to Buffalo and Cody.

Dawson: Developed by University of Nebraska and U.S. Dept. of Agriculture. Resistant to spotted alfalfa aphid and pea aphid. Wilt resistant. Winterhardy.

Florida 66: Developed by the University of Florida by recurrent selection under Florida conditions. Recommended for northern half of Florida and it has performed well in other parts of the south where winters are very mild.

This variety seems to have some resistances to leaf and crown diseases common in the South.

Sonora: Developed by the University of Arizona. Non-winterhardy variety adapted to lower desert valleys areas of Arizona, California, and Nevada.

Delta: Developed by Mississippi Agricultural Experiment Station, and U. S. Dept. of Agriculture for tolerance to root and crown rots, leaf spot diseases, and leafhopper yellowing. Adapted to lower Mississippi River Valley.

African: A non-winterhardy introduction from Egypt that has performed well in the irrigated Southwest.

Hairy Peruvian: A non-winterhardy introduction from Peru that has performed well in the irrigated Southwest.

Cherokee: Developed by North Carolina Experiment Station and U.S. Dept. of Agriculture by recurrent selection under North Carolina conditions. Resistance to alfalfa rust, potato leafhopper yellowing, certain leaf spots and crown and stem rots, and generally adapted to most of the alfalfa growing area of the Southeastern USA.

Team: Developed by North Carolina Experiment Station and U. S. Dept. of Agriculture. Moderate resistance to alfalfa weevil, pea aphid and common leafspot.

Weevlchek: Developed by the Farmers Forage Research Cooperative. Winter-hardy, resistant to bacterial wilt and potato leafhopper yellowing.

Vernal: Developed by the Wisconsin Agricultural Experiment Station and U.S. Department of Agriculture. Winterhardy, highly resistant to bacterial wilt, and tolerant to leaf spot and yellow leaf blotch.

Lahontan: Developed by the Nevada Agricultural Experiment Station and the U.S. Dept. of Agriculture. Resistant to bacterial wilt, stem nematode, and spotted alfalfa aphid.

Williamsburg: Developed in Virginia by mass selection, and generally well adapted to Virginia and the Carolinas.

Of the varieties grown in the Southeastern USA, only Cherokee, Delta, Team, Florida 66, and Williamsburg were developed specifically for this area. The supply of seed of these varieties has never been adequate, and seed of these varieties has been unavailable in many areas. There probably are two reasons for this short supply of seed: (a) The alfalfa acreage in the Southeast has been too small to interest seed companies in producing seed specifically for this area, and (b) Although improvement in persistence has been made, the varieties developed in the Southeast still have serious weaknesses due to susceptibility to specific insect and diseases prevalent in this area. The

absence of a uniquely superior variety has prevented a strong farmer demand for any particular variety.

Recently, the varieties 'Victoria' and 'Apalachee' were released by the Arkansas and North Carolina Agricultural Experiment Stations, respectively. Victoria is highly resistant to the spotted alfalfa aphid, and has some resistance to common leaf spot, downy mildew, phytophthora root rot, bacterial wilt, potato leafhopper and thrip. It produces wide, low crowns, a much-branched taproot with an inherent capacity to spread by means of creeping roots or rhizomes. Apalachee is highly resistant to stem nematodes, and has some resistance to leaf and stem diseases. It produces erect growth and recovers rapidly after cutting. These varieties have the potential to contribute to increased alfalfa production in the upper-south. In reality, their acceptance and use by farmers will be determined largely by the availability of seed. More considerations need to be given to means of insuring an adequate seed supply of forage varieties adapted to the south.

Diseases

Susceptibility to disease is one of the important limiting factors to alfalfa production in the South. The warm humid climate apparently favors many pathogenic organisms and, because alfalfa has never been grown extensively in this region, resistance has not evolved through natural selection. However, many sources of disease resistance have been found in recent years, and breeding disease resistant alfalfa for the humid South should be highly successful. Several diseases of alfalfa prevalent in the South are described in the following paragraphs.

Anthracnose: This disease is caused by a fungus Colletotrichum trifolii. Moderately infected stems have small lesions at the bottom of the stems. Severely infected stems break at the lesions and crown buds die. The woody center of the crown decays and dry dead tissue develops a black or blue-black color. This disease spreads rapidly during periods of rainy weather in the summer and fall, and it greatly reduces yield and persistence. Anthracnose occurs throughout the South. Ostazeski et al. (24) developed a laboratory method for screening alfalfa seedlings for resistance to C. trifolii. Gene(s) which impart immunity to anthracnose have been discovered in several sources of alfalfa germplasm, and resistance can be transferred easily by hybridization. At present there are no anthracnose-resistant varieties on the market but recently several experimental varieties have been developed that are highly resistant.

Rhizoctonia: This disease is caused by the fungus Rhizoctonia solani Kuehn. The fungus is widespread in southern soils where it attacks cotton and many other plants. The organism attacks stems, leaves, crown buds, and roots during hot, wet weather. Hanson and Allison (13) observed differences among strains of alfalfa for susceptibility to rhizoctonia although no strains were found to be highly resistant.

Sclerotinia: This disease is caused by the fungus Sclerotinia trifoliorum Eriks, and can cause serious stand loss in some seasons. The organism causes

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most damage to the crown and roots of alfalfa in the spring but is capable of rotting the roots to a lesser extent in the summer. Abundant fungus mycelia develop on the surface of the lesions and this appears as a white, cottony mat during moist weather. Black, hard, irregularly-shaped sclerotia are formed in the white mat. These remain dormant during summer and germinate in the cool moist weather of autumn. The alfalfa plant is most susceptible to the disease during the winter. Kreitlow (19) developed a field inoculation method for inducing infection by S. trifoliorum in red and ladino clover. Allison and Hanson (1) developed a laboratory method for screening alfalfa to this organism. Differences among alfalfa varieties in susceptibility to sclerotinia have been observed in the breeding program in North Carolina but no highly resistant plants have been isolated. An alfalfa breeding program for resistance to sclerotinia is being conducted presently at the University of Maryland.

Southern Blight: This disease is caused by the fungus Sclerotium rolfsii which attacks a wide range of host plants, including grasses. The disease is evident in alfalfa in the summer when the fungus attacks stems and crown buds of the plants. The stems bleach to a light tan color and die. The fungus is widespread in silty and sandy soils in the Southern States. Sources of resistance in alfalfa are unknown.

Summer Blackstem: This disease is caused by the fungus Cercospora medicaginis. It is more a problem during summer and early autumn in contrast to the blackstem disease of spring and late autumn caused by Ascochyta imperfecta. During warm, moist weather, C. medicaginis cause leafspot disease and reduces the value of the summer cuttings of alfalfa. Brigham (3) developed a greenhouse method for screening alfalfa plants for resistance to C. medicaginis. Buffalo, Williamsburg, Atlantic and Cody are moderately resistant to this disease.

Spring Blackstem: This disease is caused by Ascochyta imperfecta and occurs in all alfalfa-growing regions of the USA. It develops during the cold, wet conditions of early spring and late autumn. Varieties with moderate resistance to spring blackstem are Ranger, Buffalo, Williamsburg, and Teton.

Bacterial Wilt: This disease is caused by the bacterium Corynebacterium insidiosum. It occurs frequently in the lower poorly-drained fields of northeastern Arkansas and infrequently in the Yazoo-Mississippi Delta area. Symptoms include dwarfing, pale color, small curled leaves yellowed at the margins, occasional wilting, and yellow or pale-brown discoloration of the woody cylinder just beneath the bark on the crown and root. Jones (17), Kreitlow (21), Frosheiser (9), and Cormack et al. (6) have described methods of screening for resistance. Resistance to bacterial wilt is highly heritable and the varieties Ranger, Buffalo, Vernal, Caliverde, Lahontan, Cody, Saranac, Scout and WL 306 are a few of many varieties and strains resistant to this disease.

Fusarium Wilt and Root Rot: This disease is caused by one or several fungi of the Fusarium Group. Cottam (7) reported a "dry rot" of alfalfa roots caused by a Fusarium in southern Utah. Plants wilted and died suddenly from

root injury caused by the fungus. Weimer (28, 29) described a wilt caused by a different species of Fusarium.

Fusarium oxysporum forma: medicaginis, in Mississippi. Hanson and Allison (13) found that this organism caused considerable depletion of stands in North Carolina. This organism was also found to be the cause of serious and rapid stand depletion in Louisiana (15). Cormack reported that in Canada, F. avenaceum and F. arthrosporides caused serious injury to roots in early spring and F. culmorum was very virulent in the summer. Wollenweber and and Rienking (30) reported that 20 species of fusarium are known to occur on alfalfa. Staten and Leyendecker (27) isolated F. solani from diseased alfalfa plants in New Mexico. Varieties that carry resistances to Fusarium wilt are Zia, Teton, and Mesilla.

Phytophthora Root Rot: This disease is caused by the fungus Phytophthora megasperma. The disease is serious in irrigated fields and in areas of poor drainage. The tap root is most affected by this disease but crown and lateral roots may also be affected. Periderm, phloem, and xylem tissue become infected. The leaves become yellow and flacid. When the roots are completely girdled, the plant wilts and dies. Several sources of resistance to phytophthora are now available and resistant varieties are being developed.

Other Root and Crown Rots: A species of Botryodiplodia causes a slow, black rot of the tap root of alfalfa plants. The fungus appears to be a slow acting parasite. Two other fungi have been isolated from alfalfa roots; i.e. Mycoleptodiscus terrestris (Gerd.) Ostazeski and Sclerotium bataticola Taub.

Common Leafspot: This disease is caused by the fungus Pseudopezia medicaginis (Lib.) Sacc., and causes small, circular brown spots on the leaflets. The fungus overwinters on dead leaves and wind spreads the disease in the spring. Jones (16) and Graham et al. (11) developed laboratory methods of screening for resistance to this disease. Genetic resistance is highly heritable and the following varieties carry resistance to common leafspot: Cherokee, Scout, Glacier, Apex, Team, Dupuits, Saranac, Victoria, and others..

Stemphylium Leafspot: This disease is caused by the fungus Stemphylium botryosum Wallr. Lesions on the leaflets develop on the summer growth of alfalfa during warm, moist periods and cause some defoliation in many years. A breeding program for genetic resistance to stemphylium leafspot is being conducted by the U.S. Dept. of Agriculture at Beltsville, Maryland.

Downy Mildew: This disease is caused by the fungus Peronospora trifoliorum By. and may cause considerable damage to the first cutting of hay and weaken the plants. The disease may be systemic in seedlings and branches of large plants. The fungus may overwinter in the buds and systemically infect spring shoots. Pedersen and Barnes (25) have shown that resistance to downy mildew is controlled by a single gene with incomplete dominance. Varieties that carry resistance to this disease are: Caliverde, Sonora, Mesa Sirsa, Atra 55, Stride, Bonanza, El-Unico, Victoria, and others.

Pepper Spot: This disease is caused by the fungus Leptosphaerulina briosiana (Poll.) Graham and Luttrell. In March, hundreds of small black flecks appear on both surfaces of the leaf blades and on the petioles, giving the plants the appearance of having been peppered. Infected leaves turn yellow and fall from the plant. Sources of resistance are unknown.

Alfalfa Rust: This disease is caused by the fungus Uromyces striatus Schroet. var. medicaginis (Pass) Arth. Alfalfa rust is characterized by reddish-brown masses of fungus spores that rupture the epidermis of the leaves. The disease is widely distributed in the southern USA. Genetic resistance is highly heritable and Cherokee and several breeding strains contain a high level of resistance.

Alfalfa Mosaic Virus (AMV): A large number of strains of AMV have been reported. The pea aphid and peach aphid transmit this disease. Leaves of infected plants may be reduced to one-third normal size and become crinkled, brittle, and somewhat deformed. Kreitlow (20) developed an inexpensive, effective method of inoculating plants with AMV. Genetic resistance to this disease is conditioned by a single recessive gene and sources of genetic resistance have been identified.

Insects

There are four major insects of alfalfa prevalent in the southern States: alfalfa weevil, potato leafhopper, pea aphid, and spotted alfalfa aphid. Of these the alfalfa weevil is by far the most devastating. These insects are discussed in the following paragraphs.

Alfalfa Weevil: The first appearance of the alfalfa weevil, Hypera postica in the United States was near Salt Lake City, Utah in 1904. This insect became an important pest in the west but did not spread to the eastern USA. In 1951, it appeared in Maryland and then quickly spread through the eastern and southern States. The eastern weevil has been particularly damaging in the Atlantic States for the past several years, greatly reducing the average planted in alfalfa. Recently, the eastern weevil has moved westwardly and now occurs in Oklahoma and Texas. The adult weevil lays her eggs in the old stems and crown buds of alfalfa plants in the late fall and winter. When alfalfa begins to grow in the spring, the eggs hatch and the larvae may completely devour the first growth. Genetic resistance has been found in one source of alfalfa germplasm and a moderately resistant variety (Team) has been developed by the North Carolina Experiment Station and the U.S. Dept. of Agriculture. Several experimental varieties with a higher level of resistance than Team are being tested, but none have shown a very high level of resistance.

Potato Leafhopper: The leaves of alfalfa plants attacked by the potato leafhopper Empoasca fabae (Harris) become yellowish and may have a bronze or purplish tint. The tender leaves and ends of branches may wilt and die. A cooperative study (22) conducted by the North Central States and some Southern States proved that E. fabae was not present in the Northern States

during the winter, but migrated north during April and May. *E. fabae* overwinters in the Gulf States at the latitude of Baton Rouge, Louisiana, and further south. Resistance to leaf hopper yellowing is highly heritable and the varieties Cherokee, Tempo, Weevlchek, Progress, Scout, Dawson, Kanza, Victoria, and others show resistance. Also, several experimental strains contain resistance.

Pea Aphid: The pea aphid (*Acrythosiphum pisum*) first appeared on alfalfa in destructive numbers around 1900. Several methods have been described for screening alfalfa plants for pea aphid resistance (18, 8, 23, 4, 26, 12, 10). Resistance is highly heritable and of the antibiosis type. Resistance is conferred by a single dominant gene (10). Varieties which carry resistance to the pea aphid are Washoe, Dawson, Mesa Sirsa, Kanza, Team and others.

Spotted Alfalfa Aphid: The spotted alfalfa aphid *Therioaphis maculata* first appeared in the USA in southeastern New Mexico in February, 1954, and spread rapidly. That same year it appeared in Arizona in May, in California in June, in Oklahoma in July, and in Nevada in October. By May, 1955, the insect had reached the Texas Panhandle, Kansas and Utah. It was found that resistant alfalfa plants could be selected from adapted varieties. Genetic resistance to the spotted alfalfa aphid is highly heritable and the varieties Moapa, Zia, Cody, Sonora, Washoe, Dawson, Kanza, Victoria, Hayden, and others carry resistance to this insect.

Nematodes

Alfalfa is attacked by the stem nematode and the root-knot nematode. These nematodes are a potential threat to alfalfa in the south, however, they are not known to be widely distributed in this area. In 1956, the stem nematode was reported in North Carolina, and later it was reported in the eastern USA from New Jersey to Alabama. In fields infested by nematodes, successful alfalfa production depends upon the planting of resistant varieties.

Stem Nematode: Plants infested by the stem nematode *Ditylenchus dipsaci* are usually dwarfed, yellow, distorted, and wilted. Stems become swollen and brown at the base and break easily. Resistance to the stem nematode is highly heritable in alfalfa and three resistant varieties have been developed: Lahontan, Washoe, and Apalachee.

Root-Knot Nematode: Three species of root-knot nematodes are known to be destructive to alfalfa, *Meloidogyne javanica*, *M. incognita*, and *M. hapla*. Hunt et al (14) incorporated root-knot nematode resistance into adapted material carrying pea aphid, spotted alfalfa aphid, stem nematode, and bacterial wilt resistance. Varieties which carry resistance to root-knot nematode are Sonora and Mesa Sirsa.

Utilization and Management Problems

With a continued breeding effort many of the weaknesses of alfalfa in the humid south can be overcome. Genetic resistance to the major insects and

diseases of alfalfa probably can be incorporated into varieties adapted to this area. However, major difficulties would still remain for successful alfalfa culture in much of the south. These difficulties are discussed in the following paragraphs.

Soil Fertility: For the most part, soils in the humid south are slightly to highly acidic. Most soils must be limed to correct pH and reduce aluminum and manganese toxicity. Also, alfalfa requires a high level of potassium and phosphorous that must be added to the soil for continued high production. This lime and fertilizer requirement tends to push the establishment cost of alfalfa rather high, often requiring a total expenditure of as much as \$80 per acre. With such an expenditure, the farmer needs dependable results. The breeding for disease and insect resistance and general adaptation in the south can improve reliability of establishment and longer persistence. Longer persistence would allow the establishment cost to be pro-rated over a longer period. It may be possible to breed for tolerance to aluminum and manganese toxicity of acid soil.

Seeding and Establishment: Alfalfa can be established with the greatest success in the south in late summer or early fall. Preemerge herbicides are helpful in controlling weeds. On soils that have not grown alfalfa previously, inoculation with nitrogen-fixing bacteria is absolutely necessary. Such soil can be successfully inoculated; however, as many as 6 months are sometimes required for complete inoculation. During this period alfalfa plants are weak and non-productive. Once soil is successfully inoculated, it will remain so for several years.

Hay Making: Most of the alfalfa produced in the humid south is made into hay. Properly-cured alfalfa hay is of high value. The high humidity of the south makes it beneficial to artificially dry the hay (once it is baled) in gas- or oil-heated, forced-air drying bins. This requires additional operating cost, capital investment, and labor. During the long growing season of the south, alfalfa must be harvested 3, 4, or 5 times - often producing annual yields exceeding 6 tons of hay per acre.

Making these multiple harvest requires management skill. Hay cut a day before a rain shower is lost. The labor requirement for hay making is high.

Haylage: To overcome problems of hay-making some large dairymen in North Carolina are putting alfalfa into gas-tight silos as haylage. Advantages are as follows:

- 1) a high quality feed is produced;
- 2) harvesting and feeding can be fully mechanized;
- 3) less subject to rain damage - the haylage is wilted to 50% moisture, and alfalfa cut in the afternoon can be stored the next morning; and
- 4) less management and labor output required.

The disadvantage for the small dairyman is the high cost of the silo. Another disadvantage to many is that haylage is for "on-the-farm consumption" and is not suitable as a cash crop.

Dehydration Products: Dehydrated alfalfa is a high quality cash crop. Some dehydration of alfalfa is being done in Oklahoma, Texas, Louisiana, and Arkansas. Some dehydration of alfalfa has been done in North Carolina and possibly other Southern States in the past. The capital investment for dehydration equipment is high - \$200,000 and more for larger operations. Lack of persistence, insect and disease damage, and difficulty in the establishment of alfalfa stands have discouraged the growth of an alfalfa-dehydration industry in the south. However, with more reliable and higher-producing alfalfa varieties, a dehydration operation could succeed on large farms. A cotton - alfalfa rotation could be made to be profitable if disease and insect problems could be overcome through breeding (2).

Grazing: Alfalfa has not been used as a pasture crop in the South. Possible reasons are:

- 1) Poor persistence due to cattle trampling;
- 2) Poor persistence due to varieties being unadapted to frequent defoliation;
- 3) Lack of knowledge of management procedures and skills; and
- 4) Threat of bloating of cattle.

The problems one may encounter in grazing alfalfa will be difficult to overcome, but it is this area of research that promises the greatest rewards. Alfalfa is a deep-rooted, perennial warm-season legume of exceptionally high nutritive value. In the South it begins growth in February or early March and continues growth through November. We have no pasture legume that produces as much forage as alfalfa and over such a long season. To successfully pasture alfalfa, the major diseases and insects will have to be conquered through breeding for genetic resistance. In addition, a new type of alfalfa plant will have to be bred. Such a plant would probably have a more vigorous and fibrous root system than hay-type alfalfa. It would probably have a heavier crown that would resist trampling, and be capable of initiating many stems. The crown would produce stem buds in an indeterminate manner so that new stems will be arising as older stems are being removed by grazing. Stems would probably contain many axillary buds that would replace the function of the terminal bud when the terminal is removed by grazing. And, a pasture-type alfalfa plant would need to be able to spread vegetatively; to fill in a stand that was established imperfectly or was reduced by overgrazing, drought, or other causes. The variety 'Victoria' and experimental creeping-root varieties developed by the North Carolina Experiment Station in cooperation with the U.S. Dept. of Agriculture have many of these properties, but much additional breeding is needed before a pasture-type alfalfa is a reality (5).

1. Allison, J. L. and C. H. Hanson. 1951. Methods for determining pathogenicity of Sclerotinia trifoliorum on alfalfa and Rhizoctonia soloni on Lotus. Phytopath. 41:1.
2. Arnold, B. L. and S. P. Crockett. Cotton tests show long lasting benefit from alfalfa. North Mississippi Branch Experiment Station, Holly Springs, Miss.
3. Bringham, R. D. 1957. Etiology of and screening methods for Cercospera disease of alfalfa. Iowa St. Coll. J. Sci. 32:141-143.
4. Brown, R. D., Pimentel and H. D. Byrne. 1969. Intrinsic rate of increase of the pea aphid on resistant and susceptible alfalfa. J. Econ. Entomol. 62:1521-1522.
5. Busbice, T. H. and C. H. Hanson. 1969. Selection for improving creeping - rooted characteristics in alfalfa. Crop Sci. 9:244-246.
6. Cormack, M. W., R. W. Peake, and R. K. Downey. 1957. Studies on methods and materials for testing alfalfa for resistance to bacterial wilt. Can. J. Plant Sci. 37:1-11.
7. Cottam, W. P. 1921. A "dry rot" disease of alfalfa roots caused by a Fusarium. Plant Dis. Rept. 11:383.
8. Dahms, R. G. and R. H. Painter. 1940. Rate of reproduction of the pea aphid on different alfalfa plants. J. Econ. Entomol. 33:482-485.
9. Frosheiser, F. I. 1966. Alfalfa inoculation with bacterial wilt inoculum prepared from infected alfalfa roots. Phytopath. 56:566-567.
10. Glover, D. V. and E. H. Stanford. 1966. Tetrasomic inheritance of resistance in alfalfa to pea aphid. Crop Sci. 6:161-165.
11. Graham, J. H., R. R. Hill, D. K. Barnes, and C. H. Hanson. 1965. Effects of three cycles of selection for resistance to common leafspot in alfalfa. Crop Sci. 5:171-173.
12. Hackerott, H. L., E. L. Sorensen, T. L. Harvey, E. E. Ortman and R. H. Painter. 1963. Reactions of alfalfa varieties to pea aphids in the field and greenhouse. Crop Sci. 3:298-301.
13. Hanson, C. H. and J. L. Allison. 1950. Studies on the nature and occurrence of stand depletion in alfalfa strains in North Carolina. Agron. J. 43:375-379.
14. Hunt, O. J., R. N. Peaden, L. R. Faulkner, G. D. Griffin, and H. J. Jensen. 1969. Development of resistance to root-knot nematode (Meloidogyne hapla Chitwood) in alfalfa (Medicago sativa L.) Crop Sci. 9:624-627.

15. Jenkins, J. H. and G. D. Lindberg. 1961. Fusarium wilt of alfalfa in Louisiana. *Phytopath.* 51:643.
16. Jones, F. R. 1919. The leaf-spot diseases of alfalfa and red clover caused by the fungi *Pseudopeziza medicaginis* and *Pseudopeziza trifolii* respectively. *U.S.D.A. Bull.* 759. p. 38.
17. Jones, F. R. 1930. Bacterial wilt of alfalfa. *Jour. Amer. Soc. Agron.* 22:568-572.
18. Jones, L. G., F. N. Briggs and R. A. Blanchard. 1950. Inheritance of resistance to the pea aphid in alfalfa hybrids. *Hilgardia* 20:9-17.
19. Kreitlow, K. W. 1951. Infection studies with dried grain inoculum of Sclerotinia trifoliorum. *Phytopath.* 41:553-558.
20. Kreitlow, K. W. 1961. The pipe cleaner; an inexpensive tool for inoculating plants with viruses. *Phytopath.* 51:808-809.
21. Kreitlow, K. W. 1963. Infecting seven-day-old alfalfa seedlings with wilt bacteria through wounded cotyledons. *Phytopath.* 53:800-803.
22. Medler, J. T. 1957. Migration of the potato leafhopper - a report on a cooperative study. *J. Econ. Entomol.* 50:493-497.
23. Ortman, E. E., E. L. Sorensen, R. H. Painter, T. L. Harvey and H. L. Hackerott. 1960. Selection and evaluation of pea aphid resistant alfalfa plants. *J. Econ. Entomol.* 53:881-887.
24. Ostazeski, S. A., D. K. Barnes, and C. H. Hanson. 1969. Laboratory selection of alfalfa for resistance to anthracnose (Colletotrichum trifolii). *Crop Sci.* 9:351-354.
25. Pederson, M. W. and D. K. Barnes. 1965. Inheritance of downy mildew resistance in alfalfa. *Crop Sci.* 5:4-5.
26. Smith, O. F. and R. N. Peaden. 1960. A method of testing alfalfa plants for resistance to the pea aphid. *Agron. J.* 52:609-610.
27. Staten, G. and P. J. Leyendecker. 1949. A root rot disease of alfalfa caused by Fusarium soloni, *Plant Dis. Reptr.* 33: 254-255.
28. Weimer, J. L. 1927. A wilt disease of alfalfa caused by Fusarium spp. *Phytopath.* 17:337-338.
29. Weimer, J. L. 1928. A wilt disease of alfalfa caused by Fusarium oxysporum var. medicaginis, n. var. *J. Agr. Res.* 37:419-433.
30. Wollenweber, H. W. and O. A. Reinking. 1935. Die Verbreitung der Fusarien in der Natur. R. Friedlander und Soh, Berlin. 80 pp.

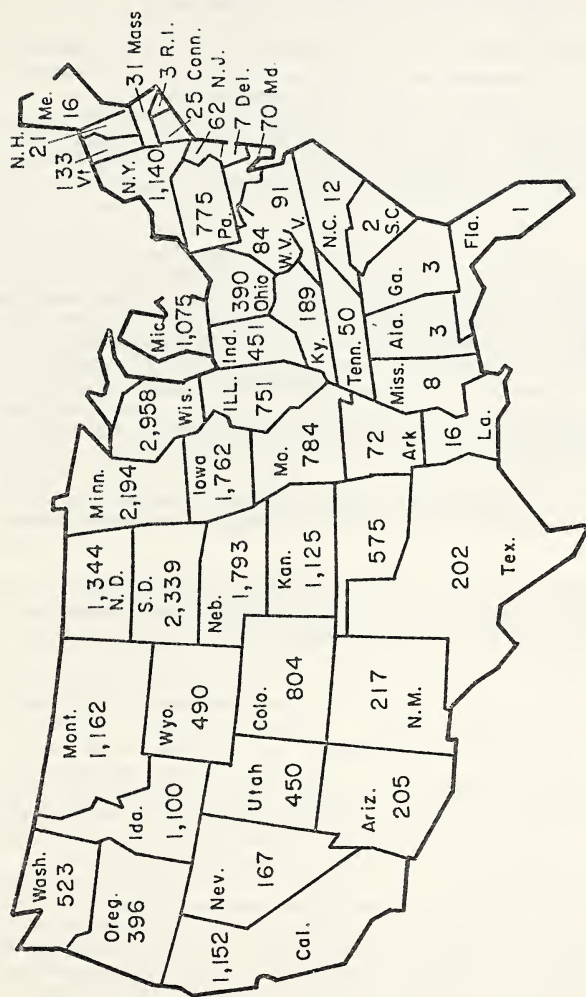


Figure 1. Approximate acres of alfalfa and alfalfa mixtures presently grown for hay. Units are given in Thousands. Data taken from 1970 agricultural census and communications with agricultural specialist in several states.

Barriers to Improving Forage Digestibility
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A number of chemical compounds have been identified with reduced forage digestibility. Among those so impugned are perloine fescue (1) and tannins in a number of plants (3, 4). Lespedeza has been shown to have a polyphenolic inhibition of cellulase activity (9). Most of these compounds influence digestion through their effect on the rumen microflora or their enzymatic functions. Many other compounds are probably toxic to the microorganisms or at least reduce their efficiency when present in sufficient quantity.

There are also present in forages, compounds which are themselves indigestible and in addition may limit the rate of digestion of other components. Three of the most important of these are lignin, silica and cutin (11). These may also be classified as non-nutritive residues (10): The importance of lignin has bng been recognized and it has been a basis for determining forage quality. Silica content has often been considered a contaminant in forage samples. However, metabolized silica may be a very important factor affecting digestibility of structural carbohydrates (11). The effects of cutin have received less attention. It is a very impervious layer on many plant parts and may impede digestion in many instances (5, 8).

All of the above barriers to digestion of forage have been studied and documented. In some cases progress has been made through breeding to reduce their effects.

In the remainder of this presentation I wish to emphasize some barriers to digestion of fresh forage in rumen fluid. Recent studies in our laboratory have permitted a closer look at the rate and progression of digestion of green forage (5, 6).

A 2-stage in vitro procedure is routinely used in our laboratory for digestible dry matter evaluations of dried forages. To our knowledge, there exists no in vitro procedure to assess the nature and extent of digestion of fresh forage in rumen fluid. Some studies, Reid, et al. (7) and some unpublished work in our laboratory indicate that fresh chopped forage is generally lower in digestibility than expected. Johnson et al. (2) ground fresh forage with dry ice and found it more digestible than dried forage after 12 hours. This suggests as pointed out by Reid et al. that fresh forage chopped or cut in small pieces is relatively unavailable for digestion. A laboratory procedure which permits examination of forage particles after various periods of incubation in rumen fluid could reveal much of the progress of digestion. Sakurai (8) has studied microscopically the digestion of forage particles by isolating fragments of forage from feces of animals. This is a laborious procedure not suited to routine evaluation of forage samples. These considerations led us to develop a method for evaluation of the digestion of fresh forage in vitro.

The digestion in pearl millet inbred line 23A measured at 6, 12, 24 and 48 hours progressed from the cut surface inward with very little digestion noticeable for periods shorter than 6 hours (5). The rate of digestion was slower in Napier grass leaves than in the pearl millet. In all cases, the cuticle was an effective barrier to digestion. In Tift 23A, the cuticle has become sufficiently detached that it can be recovered intact after 48 hours of digestion.

Coastal and Coastcross-1 bermudagrasses were compared using this procedure with digestion times of 12, 24, 48 and 72 hours. The digestion of Coastcross-1 bermudagrass is first visible after 24 hours. Thereafter it proceeds to a greater extent than does Coastal. Future studies of cuticle thickness, fiber structure and other anatomical features in relation to the digestion process of these two varieties should prove rewarding.

A rather large difference in the digestion of leaf segments occurs not only among species but between genotypes within species. These differences generally reflect previously measured differences in dry matter digestibility, but rate of digestion also varies. The technique we have used make it comparatively easy to observe the progress of digestion and particularly the rate of digestion of fresh forage.

We feel that the technique has exciting possibilities beyond measuring digestibility. It should make it possible to study microscopically the process of digestion almost cell by cell. The procedure also offers promise in anatomical studies. The intact cuticle can be easily recovered and the remaining leaf skeleton is available for detailed study of the indigestible fraction.

Digestion can be blocked by sealing the cut ends of a green leaf section with wax. As long as the cuticle remains intact, no digestion will occur. The rate of digestion can also be enhanced by puncturing the leaf surface repeatedly with a needle. It seems certain that any processing of fresh forage which ruptures the cuticle or reduces particle size will increase rate and probably extent of digestion.

Effects of Treatments

Preliminary work indicated increased digestion of fresh forage by increasing the number of cut surfaces, perforating the leaf with coarse sand paper, or abrading the leaf surface with fine sandpaper.

The effects of cutting leaves of 5 forages to various lengths are shown in Table 1 (6). In every case, IVDMD% was increased as the number of cut surfaces increased. The increase was greatest for Tift 23 pearl millet and least for Coastal bermuda. Reducing the length of cut from 2.5 to .3 cm approximately tripled the dry matter digestibility of Tift 23 millet, Napiergrass and 393 bermuda, and doubled the digestibility of Tift 18 millet and Coastal bermudagrass. Differences were highly significant ($P < .01$) for both treatments and grasses. Thus it appears that increased cut surface

renders plant leaves more accessible to digestion as suggested earlier (5).

The 48 hour IVDMD of the same five grasses plus Coastcross-1 bermudagrass after perforating or abrading the leaf surface was dramatically increased (Table 2) (6). The IVDMD% of the two millets and Napier grass was increased 2.5 to 3-fold and the bermudagrasses 4 to 5-fold. Statistical analysis of the data showed a highly significant (P 01) difference between treatments and grasses.

Histological Studies

The in vitro digestion of fresh bermudagrass and pearl millet leaves after 12, 48 and 96 hours in rumen fluid was studied histologically. Our observations indicate that the relative amounts of the leaf made up by vascular bundles, cutinized and lignified walls, mesophyll and other anatomical structures varied between varieties within a species. The rate at which digestion progressed through the leaf tissue also varied between varieties indicating a permeability factor. The variation observed indicates that forages of higher digestibility could be obtained by breeding for cell types and arrangements that rumen micro-organisms readily digest. The micro-organisms consistently digested the larger and less compactly arranged cells of the mesophyll first. Bundle sheath cells and other cutinized or lignified cell walls remained undigested after 96 hours in rumen fluid.

Literature Cited

1. Bush, L. P., C. Streeter, and R. C. Buckner. 1970. Perloine inhibition of in vitro ruminal cellulase digestion. Crop Sci. 10:108-109.
2. Johnson, R. R., B. A. Dehority, H. R. Conrad, and R. R. Davis. 1962. Relationship of IVCD of undried and dried mixed forages to their in vitro DMD. J. Dairy Sci. 45:250.
3. Cope, W. A., and J. C. Burns. 1971. Relationship between tannin levels and nutritive value of sericea. Crop Sci. 11:231-233.
4. Cummins, D. G. 1971. Relationships between tannin content and forage digestibility in sorghum. Agron. J. 63:500.
5. Monson, Warren G., Jerrel B. Powell, and Glenn W. Burton. 1972. Digestion of fresh forage in rumen fluid. Agron. J. 64:231.

6. Monson, Warren G., and Glenn W. Burton. 1972. Effects of length of cut and leaf surface treatment on digestibility of fresh forage. Agron. J. 64:405-406.
7. Reid, R. L., G. A. Jung and S. Murray. 1964. The measurement of nutritive quality in a bluegrass pasture using in vivo and in vitro techniques. J. An. Sci. 23:700-710.
8. Sakurai, M. 1963. Histological studies of the decomposition of their tissue to pasture grasses or livestock digestion. Research report No. 5, Grassland Div. Kanto-tosan Agr. Exp. Sta.
9. Smart, W. W. G., Jr., I. A. Bell, Nancy W. Stanley, and W. A. Cope. 1961. Inhibition of rumen cellulase by an extract from sericea forage. J. Dairy Sci. 44:1945.
10. Van Soest, P. J. 1966. Non-nutritive residues: A system of analysis for the replacement of crude fiber. J. Assoc. Official Analytical Chemists. 49:546.
11. Van Soest, P. J. 1969. The chemical basis for the nutritive evaluation of forages. National Conference on Forage Quality and Utilization. PU-1-19.

Table 1. Effect of length of cut on IVDMD% of Leaves of 5 Forages

Forage	DM Loss in 48 hr. when cut to:			
	2.5 cm	1.2 cm	0.6 cm	0.3 cm
Millet - Tift 23A	22.0	42.8	55.4	63.6
Millet - Tift 18	27.4	34.0	38.1	57.2
Napiergrass	17.0	23.1	30.2	45.2
Coastal Bermuda	10.4	13.8	15.2	22.0
393 Bermuda	8.6	15.6	14.0	26.0
Average	17.1	25.9	30.6	42.8

LSD .05 Varieties - 10.5, Treatment 8.3

LSD .01 Varieties - 14.6, Treatment 11.2

Table 2. Effect of Two Leaf Treatments on IVDMD% of 6 Forages

Forage	48-hr IVDMD of 2.5 cm segments		
	Intact	Perforated ^{1/}	Sanded ^{2/}
Millet - Tift 23A	22.0	70.7	77.2
Millet - Tift 18	27.4	68.5	66.3
Napiergrass	17.0	46.1	48.6
Coastal Bermuda	10.4	41.7	40.5
393 Bermuda	8.6	46.0	45.3
Coastcross-1	16.5	48.1	48.7
Average	17.0	53.5	54.4

LSD .05 Variety = 8.2, Treatment = 4.9

LSD .01 Variety = 11.9, Treatment = 6.7

^{1/} Pressed against coarse sandpaper

^{2/} Abraded with fine sandpaper

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Pasture and harvested forages of high quality are usually the cheapest source of feed nutrients required by dairy and beef animals for growth, body maintenance, or milk production. This is particularly true when forages are properly supplemented to furnish the animal with a balanced dietary intake of nutrients.

The most important thing of which to be aware when evaluating a forage as feed for cattle is "What characteristics make this a valuable feedstuff?".

Forages contain practically all of the essential nutrients required for cattle; however, the amount of these nutrients varies with the type of forage and the conditions under which the forage is produced. A high quality forage would be one that has a high amount of essential nutrients in a well balanced proportion. In addition, it needs to be physically attractive, palatable, and digestible. In comparison, a low quality forage would contain less essential nutrient, would be less palatable, and would be less digestible.

Ruminants are custom built for forage utilization. With the aid of millions of microorganisms in the rumen compartment of the stomach forages can provide most of the nutrients needed in a balanced ration for cattle.

When feeding cattle, we are basically concerned with five classes of nutrients. These are water, energy, protein, minerals, and vitamins. It is important to understand these nutrient needs in order to properly feed cattle and in order to produce forages of high nutritive value. In one sense, the cattleman is at the mercy of the agronomist. If a forage of sufficient quality to meet the animal's needs is not available, expensive supplemental feeds are needed.

With this in mind, let's discuss these five classes of nutrient needs for beef cattle in relationship to the nutrient content of forages.

Water: Sufficient water intake by cattle to satisfy the needs of normal body processes is of great practical importance. To insure adequate water intakes, it is desirable to supply plenty of water to cattle at all times. Only when extremely young, succulent pastures are grazed will the animal satisfy its water requirements by eating forages. Therefore, let's list water as our first supplemental need when feeding legumes to cattle.

Energy: Basically there are two methods for expressing the energy value of a feed. One method is to use the net energy values for a particular feedstuff. The other method is based on total digestible nutrients in the feed.

The net energy system is probably the most precise of the two since it is based on the animal's requirement for body maintenance and its needs for production. Most feeds, and especially forages, are more efficiently utilized.

for body maintenance than for production.

The total digestible nutrient (TDN) content of a feed is a good indicator of inherent energy value and is usually sufficient for a general description of forages. The TDN content of a forage is affected by several factors with perhaps the most important being stage of maturity.

As a forage plant matures, the protein and available energy fractions decrease in content while the fiber content increases. This is evident when we compare alfalfa hay cut in the pre-bloom stage to mature alfalfa hay. The digestible protein drops from 11.7 to 9.5% and the TDN drops from 63 to 55%. At the same time, the crude fiber fraction increases from 28.5% in the pre-bloom stage to 37.5% in the mature stage. The digestibility of all nutrient constituents, including fiber, decreases as the plant matures.

Protein: Cattle need digestible protein for growth, maintenance, and production. The amount required depends on age, size, and the purpose for which the animal is kept. The amount of protein in forages varies greatly. Legumes generally contain a larger amount of protein than grasses, especially in more advanced stages of maturity. However, the protein in both grasses and legumes is more digestible in the early stages of growth than when more mature.

Minerals: As a general rule forages are excellent sources of calcium. This is especially true of legumes and forage mixtures containing legumes. Under most production systems, especially when properly fertilized, legumes and legume grass mixtures will fulfill the phosphorus requirement for most classes of cattle. Likewise, most minor elements are provided in a forage diet. The only mineral elements consistently lacking in a forage diet containing legumes are sodium and chlorine or common salt. The use of trace mineralized salt mixed 50:50 with either steamed bone meal or defluorinated rock phosphate insures that mineral requirements will be met.

Vitamins: Fulfilling the vitamin requirements of cattle past the baby calf stage is a simple task compared to fulfilling that of other species of animals. In fact, when a high quality forage is fed, there is no need for vitamin supplementation.

The water soluble vitamins (B vitamins) are synthesized by rumen micro-organisms in sufficient quantities to meet the animal's needs when the rumen is functioning properly.

The vitamin A requirement of cattle is easily met by the conversion of carotene to vitamin A in feedstuffs. Cattle can store vitamin A and carotene in the liver and in body fat during times of abundant intake and use these stores to meet their needs at a later time.

Vitamin D is synthesized by cattle when exposed to direct sunlight. In addition, sun cured hay is an excellent source of vitamin D. Therefore, only under very unusual circumstances will vitamin D supplementation be necessary.

Natural feedstuffs generally contain sufficient amounts of vitamin E to meet the requirements of cattle. Since green feeds are excellent sources of vitamin E, this would be especially true when forages are fed.

Vitamin K is synthesized in the rumen in adequate amounts under most feeding conditions. One exception occurs when a moldy hay containing a high content of dicumarol is fed. Our most frequent offender is moldy sweetclover. When such hay is consumed by cattle, the dicumarol interferes with vitamin K and results in the failure of the normal blood clotting mechanism.

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The Case for Annual Legumes in the Southeast

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The advent of high-yielding warm-season grasses which responded well to nitrogen fertilizer suggested that forage legumes were doomed in the southeastern United States. Nitrogen salesmen launched a massive campaign to sell their product. Federal and State researchers and extension personnel got on the grass-nitrogen bandwagon while legumes were neglected. Today, there is an increasing interest in legumes, not only by good cattlemen (who always knew legumes were a good thing) but by research and extension people in the Southeast.

Why Legumes?

Why do we need pasture legumes? The answer is given in the conclusions of a well-publicized grazing experiment with beef cows and calves on flatwoods soil in northern Florida (Koger, et al. 1961). Although the legume in this test was primarily perennial white clover, the results are pertinent to our discussion. They concluded that clover-grass pastures produced beef at approximately 60% of the cost for all-grass pastures fertilized with nitrogen. Clover-grass pastures resulted in a higher weaning percent, heavier calves, and a substantially lower cost per head for maintaining brood cows. Clover improved the seasonal distribution of forage and furnished higher quality grazing than grass alone.

Why Annual Legumes?

Perennial legumes offer a big advantage over annuals in that they do not need to be re-established each year, generally permitting a longer productive season. Thus, where perennials such as ladino clover or birdsfoot trefoil thrive, they are the obvious choice and should be grown when soil conditions permit. It is unlikely that annual legumes offer much promise in the Upper South. In the Lower South, ladino clover persists and is productive only on soils with good water-holding capacity or a high water table. However, these soils constitute some of our most productive row crop land. It is difficult to make a case for ladino clover-grass pasture on land capable of producing 50 bushels/acre of soybeans! Consequently, in the future we can expect beef

cattle pastures to be relegated to droughty upland soils.

Most improved pastureland in the Lower South is now planted in warm season perennial grasses such as bahia, bermuda, dallis or pangola. Nitrogen fertilization stimulates high dry matter yields of bermuda, bahia, and pangola in summer. Unfortunately, these grasses are dormant or unproductive 4 to 6 months of the year. However, temperature and rainfall in late winter and early spring are favorable for growth of many cool season forage species. Winter annual legumes lengthen the grazing season and provide higher quality forage not only on warm season grass sods (Knight 1970) but in association with small grains and ryegrass on prepared land (Holt et al. 1958; Hoveland 1969).

A few examples illustrate the value of winter annual clovers in improving performance of autumn-born calves. In a 4-year central Alabama experiment beef cows and calves were grazed on bahia and bermudagrass fertilized with 100 lb/A N (Cope et al. 1969). Where ball and crimson clovers were overseeded on the grass sod, acres per cow-calf unit were reduced from 1.75 to 1.5 acres and calf weaning weight increased from 464 to 494 pounds. On a sandy Coastal Plain soil in south Alabama, beef cows and calves were grazed on N-fertilized Coastal bermudagrass for 2 years (Evens et al. 1972). Sale weight of calves on the all-grass pasture was only 363 pounds as compared with 478 pounds for calves on Coastal bermudagrass overseeded with crimson and Yuchi arrowleaf clovers. In the Piedmont of Alabama, beef cows and calves were grazed for 3 years on Coastal bermuda fertilized with 100 lb/A N and overseeded with Yuchi arrowleaf clover (Hoveland et al. 1972). Calf gains ranged from about 2.5 pounds per day with clover in the sward to 1 pound or less when clover was absent. Yuchi arrowleaf furnished clover grazing from the first of April until July. Calf gains averaged 310 pounds per acre on the clover-grass as compared with only 180 pounds per acre in the preceding 4 year period when no clover was planted on Coastal bermuda fertilized with the same rate of N.

Legumes may help maintain animal gains over a long season on small grain pastures. On hilly Piedmont land in Alabama over a 4-year period, yearling steers were grazed continuously on rye-ryegrass-Yuchi arrowleaf clover from November 24 to June 6 at a stocking rate of 1 to 2 steers per acre (Anthony et al. 1971). Gains were 395 pounds per steer, with an average daily gain of 2.0 pounds. Feed cost of gain on pasture was only half that of steers fed corn silage. In the Tennessee Valley of northern Alabama, yearling steers grazed from October to late December and early March to June (Harris et al. 1972). Gains were 2.0 pounds per steer on small grain-ryegrass with Yuchi arrowleaf clover as compared to only 1.4 pounds on small grain ryegrass. In Arkansas, crimson clover increased both daily gain and gain per acre of lambs grazing wheat (Spooner 1964).

The value of summer annual legumes such as annual lespedezas in improving cattle gains is well-recognized (Henson, Baldridge, and Helm 1962). Stylosanthes humilis is a vigorous productive summer legume used for pasture in southern Florida (Kretchmer 1968). Other summer annual legumes which appear promising in the Lower Coastal Plain and peninsular Florida are jointvetch (Aeschynomene americana) and several species of Dolichos and

Desmodium. There is a pressing need for improved summer legumes that can be grown in association with perennial grasses. These legumes will not match the high forage yields of summer perennial grasses fertilized with high rates of N. However, the low daily gains generally obtained on these grass pastures suggest that even a modest increase in animal performance by legumes would be profitable.

What Annual Legume Species?

The tremendous number of annual legumes available in the Southeast has been a handicap as well as a benefit. The large number of species available has probably discouraged management and utilization research, as well as breeding and seed production. However, as we recognize the wealth of plant material available, breeding programs should be able to develop cultivars for the diverse soil conditions in the region.

Some annual legume species currently used in the Southeast are:

Warm season

Striate lespedeza
Korean lespedeza
Hairy indigo
Alyce clover
Stylosanthes humilis

Cool season

Crimson Clover
Arrowleaf clover
Persian clover
Ball clover
Hairy vetch
Common vetch
Lupines
Caley or rough pea

Many problems exist in the use of these legumes for pasture. In most cases, research is needed to develop methods of managing and utilizing them more effectively in grazing systems. Opportunities exist for improvement in yield, quality, and persistence of these species by plant breeding.

Conclusions

Annual legumes have an important role in improving pastures of the Lower Southeast where perennial cool season legumes often do not persist. Their value should not be judged solely on forage yield or the amount of N fixed and made available to associated grasses but rather on the extended grazing season and improved forage quality. Annual legumes can be expected to improve animal gains at relatively low cost, a necessity for production of weaner calves or stocker steers.

Literature Cited

1. Anthony, W. B., C. S. Hoveland, E. L. Mayton and H. E. Burgess. 1971. Rye-ryegrass-Yuchi arrowleaf clover for production of slaughter cattle. Auburn Univ. (Ala.) Agr. Exp. Sta. Circ. 182.

2. Cope, J. T., Jr., C. C. King, T. B. Patterson and S. C. Bell. 1969. Legumes vs. nitrogen for summer pastures. Auburn Univ. (Ala.) Agr. Exp. Sta. Highlights of Agr. Res. Vol. 16, No. 2.
3. Evans, E. M., W. B. Anthony, R. R. Harris, V. L. Brown, C. C. King, and S. C. Bell. 1972. Crops or cattle, or both, for productive land. Auburn Univ. (Ala.) Agr. Exp. Sta. Highlights of Agr. Res. Vol. 19, No. 1.
4. Harris, R. R., C. S. Hoveland, J. K. Boseck, and W. B. Webster. 1972. Wheat, oats, or rye with ryegrass and arrowleaf clover as grazing for stocker beef steers. Auburn Univ. (Ala.) Agr. Exp. Sta. Circ. 197.
5. Henson, P. R., J. D. Baldridge, and C. A. Helm. 1962. The lespedezas. Pp. 169-179. In H. D. Hughes, M. E. Heath, and D. S. Metcalfe. Forages--The science of grassland agriculture. Iowa State Univ. Press, Ames, Iowa.
6. Hoveland, C. S., W. B. Anthony, E. L. Mayton and H. E. Burgess. 1972. Pastures for beef cattle in the Piedmont. Auburn Univ. (Ala.) Agr. Exp. Sta. Circ. 196.
7. Hoveland, C. S., E. L. Carden, G. A. Buchanan, E. M. Evans, W. B. Anthony, E. L. Mayton, and H. E. Burgess. 1969. Yuchi arrowleaf clover. Auburn Univ. (Ala.) Agr. Exp. Sta. Bull. 396.
8. Holt, E. C., P. R. Johnson, M. Buckingham, H. C. Hutson, J. K. Crouch, and J. R. Wood. 1958. Pasture, hay, and silage crops for east Texas. Texas Agr. Exp. Sta. Bull. 893.
9. Knight, W. E. 1970. Productivity of crimson and arrowleaf clovers grown in a Coastal bermudagrass sod. Agron. J. 62:773-775.
10. Koger, M., W. G. Blue, G. B. Killinger, R. E. L. Greene, H. C. Harris, J. M. Meyers, A. E. Warnick, and N. Gammon, Jr. 1961. Beef production, soil and forage analyses, and economic returns from eight pasture programs in North Central Florida. Fla. Agr. Exp. Sta. Bull. 631.
11. Kretchmer, A. E., Jr. 1968. Stylosanthes humulis. Fla. Agr. Exp. Sta. Circ. S-184.
12. Spooner, A. E. 1964. Lamb grazing trials on winter supplemental pastures. Ark. Agr. Exp. Sta. Bull. 689.

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The Place for Annual Legumes in The Southeast--An Economists's Viewpoint

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The problem of evaluating the place for annual legumes in a livestock

production program is no different, from an economic viewpoint, from the problem of evaluating any forage crop. That is, our objective is to find the combination of forages that will maximize profits to the resources used in livestock production, or the least-cost combination of forages for some given level and kind of livestock production. Thus, we can't evaluate the place for legumes in a vacuum--we must approach the problem from a "total systems" standpoint if we are to have any assurance of obtaining the "right answers." This suggests that much of the past research in forage evaluation has not necessarily resulted in the kind of data needed for systems analysis, and I think that most of you will agree with this, because available results have been too fragmentary to piece together into a total system of forage production and utilization. I hasten to add that the economist must share a large part of the blame for the limited nature of much of the past research in this area. Economists generally have not worked closely enough with animal scientists and agronomists in designing experiments that yield all the information required for systems analysis.

We see much evidence today that this situation is rapidly changing. At Mississippi State, for example, there has been much emphasis during the last 2 years on interdisciplinary research. A team approach is now employed on all major new projects in forage production and utilization, as well as in other areas of research. I believe that a major role of the economist serving on interdisciplinary teams is to specify economic models that are consistent with the motives and limitations of producers to which the research is ultimately aimed, and to cooperate with the scientist representing the technical departments to assure that data needed for economic models are obtained from the research.

I would like to present to you an approach that I'm using in evaluating the production and utilization of forage crops, including legumes, and discuss some of the data requirements for this approach. First of all, it is a linear programming model, and requires a computer for solution. For those of you who are not familiar with linear programming, and I assume that most of you are not, it is a technique that permits the organization of a large number of production activities in such a manner as to maximize profits, or minimize cost, subject to specified constraints. Thus, linear programming lends itself very well to the problem of evaluating the place for legumes in a total forage program, whether the forage is utilized by beef, dairy, or any other kind of livestock.

The model is a profit maximizing model and applies to a cow-calf operation where calves can either be sold at weaning, or can be carried over for additional gain, whichever is more profitable.

The model was designed to help solve a major problem facing cow-calf producers. That is, beef cattle must basically satisfy their nutritional needs on a daily basis throughout the year, whereas, forage crops produce at rates which vary tremendously throughout the year. For example, it is estimated that 48 percent of the total production from Coastal bermudagrass in the Brown Loam area in Mississippi occurs in June and July. Different forage crops reach their peak production at different times of the year; however,

most perennials found in the Southeast tend to reach peak production in the late spring and early summer. Thus, the problem of meeting the nutritional needs of a cow-calf herd, as estimated in Table 1, from the many alternative forages, both grazed and stored, shown in Tables 2 and 3, in such a manner to maximize profits, presents a complex problem. Not only are there numerous alternative forage crops and combinations of crops, both grazed and stored, that can be combined to meet the daily nutritional needs of the cow-calf herd, but these crops can be managed in various ways that can affect their nutritional value. For example, it is well known that young, tender fescue is more digestible per unit of dry matter than fescue which has been stockpiled for four months. Thus, the problem of efficiently producing and utilizing forages becomes extremely complex.

As stated earlier, linear programming is an acceptable technique for solving such a problem, provided appropriate data can be obtained. The required data can be grouped into three major classes: (1) costs and returns, (2) nutritional requirements of beef cattle, and (3) productivity and nutritional content of forages. It is the latter two classes of data that most of you are interested in, and these are the data most limiting to economic analysis of alternative forage production and utilization systems. Nutritional requirements of beef cattle in various stages of the production cycle form some of the basic constraints in the linear programming model; i.e., minimum energy and protein requirements must be met without exceeding stomach capacity. Productivity and nutrient content of alternative forages throughout the year must also be known in order to determine how forages can best be combined to meet animal requirements.

Nutritional Requirements of Beef Cattle

There has been a substantial amount of research during the last several years concerned with the problem of deriving nutritional requirements of beef cattle. Probably the most important contribution from the economist's viewpoint was made by the National Research Council's Subcommittee on Beef Cattle Nutrition, whose work was first published in 1963. The fourth revised edition was published in 1970^{1/}. While all the NRC data on requirements were based on published experimental results, the important contribution of the Subcommittee on Beef Cattle Nutrition was the pulling together of many independent pieces of research and summarizing them in a consistent and useful manner.

The monthly nutritional requirements of a beef cattle herd depend on the magnitude of several variables such as time of calving, calving percentage, weight of brood cows, level of milk production, and desired rate of gain for calves and replacements. The NRC data are not sufficiently detailed to fit all possible situations; consequently, quite a lot of interpolation and

^{1/} National Academy of Sciences, National Research Council, "Nutrient Requirements of Beef Cattle," Fourth Revised Edition, Washington, D.C., 1970.

estimation are necessary to derive monthly nutritional requirements for any one specified level of the important variables. For example, the NRC requirements for cows are given for only two periods throughout the gestation-lactation cycle. Requirements are given for (1) maintaining dry pregnant cows in six weight classes and (2) lactating cows in four weight classes during the first 3 - 4 months after calving. No allowances are made within these two periods for weight changes of cows or their calves, changes in level of milk production, and etc., over the production cycle, when, in fact, energy requirements for a cow unit may change as much as 34 percent during lactation.

Although the NRC minimum requirements were not published in a form to fit all situations needed for this analysis, some of the underlying relationships reflected in the data proved to be extremely useful in adjusting the data to the desired form. The underlying relationships were determined using regression techniques, and incorporated in a computer program that allows specification of magnitude of most of the important variables that affect nutritional requirements. This computer program was used to derive the requirements given in Table 1.

Two important variables affecting the level of nutritional requirements are body weight, and changes in body weight. Average change in weight of brood cows by months throughout lactation and gestation were obtained from published data. It was assumed that cattle would be fed at a rate to achieve these weights.

Average daily milk production from time of calving until the calf is weaned at 7 months of age^{2/} is computed by the computer program using an equation reported by Pope.

Nutrient requirements for brood cows are computed by the program by calculating requirements for maintenance and fetal development, plus requirements for milk production. Energy requirements for maintenance, weight changes and fetal growth during lactation were computed using a regression equation developed by Smithson.^{3/} Additional energy required for milk production during this period is based on data reported by Crampton and Harris.^{4/}

Average daily energy requirements for dry, pregnant cows (final 5 months of gestation)^{5/} are estimated from a regression equation, obtained by fitting NRC data.^{5/} Energy required is a function of body weight, and changes in body

^{2/} Pope, L.S., et al., "Factors Affecting Milk Production of Range Beef Cows," Okla. Agr. Exp. Sta. Misc. Pub. MP-70, June, 1963, p. 73.

^{3/} Smithson, Larry Joe, "Energy Requirements of Mature Beef Cows as Influenced by Body Size," Unpublished Ph.D. Thesis, Okla. State Univ., May 1968, p. 29

^{4/} Crampton, E. W., and L. E. Harris, Applied Animal Nutrition, 2nd edition, W. H. Freeman and Company, San Francisco, 1969, p. 422.

NAS-NRC, Op. Cit., Table 2.

weight, as explained above.

Procedures used for computing average daily digestible protein requirements were similar to those used for computing energy needs, thus an equation was obtained by fitting NRC data. With an adjustment for varying levels of milk production, the equation predicts well the published data on protein requirements of cows.

Nutrient requirements of suckling calves were obtained from published data and added to the brood cow's requirements. It was assumed that all nutritional needs of calves are obtained from milk until the calves are 2 months of age. From 3 to 7 months of age, net requirements were derived by subtracting from total requirements the nutrients obtained from milk.

NRC data include nutritional requirements for growing and finishing steers and heifers for only a few specified weights. Thus, it was necessary to estimate average calf weights by month for three rates of gain, and then interpolate the NRC data to obtain estimates of monthly requirements of digestible energy and digestible protein. The requirements for replacement heifers were estimated similarly, and also included in the computer program. The requirements for a mature herd bull of any specified weight were estimated from regression equations which were also obtained by fitting NRC data.

The computer program has as output average daily requirements of digestible energy and protein by month, beginning with the month of calving. The requirements in Table 1 are for one bull unit consisting of 25 mature cows weighing an average of 1,200 pounds just prior to calving, 22 calves (88 percent calving rate) gaining an average of 1.1 pounds per day, three 1-year old and three 2-year old replacements (12 percent culling and/or death rate) and one bull weighing 1,800 pounds. A spring calving program is assumed, where 20 percent of cows calve in January, 60 percent calve in February, and 20 percent calve in March.

Table 1 also includes estimated maximum dry matter intake by month for a bull unit, which also forms a constraint in the linear programming model. The data were obtained by calculating average weight of the herd in each month and multiplying by .025.

Forage Production and Nutrient Content

After having estimated nutritional requirements, monthly productivity and nutrient content of alternative forages were estimated. As you well know, determining the value of forages quantitatively is a rather complex and difficult problem, particularly when several periods throughout the year are involved. Considering the wide range of forages available, there is a tremendous variation in nutritional value to cattle because of variations in dry matter intake and nutritive content. The factors in forage that determine how much of it animals consume also determine to an important extent its nutritive value.^{2/} Raymond found it useful to consider forage intake as 7/Raymond, W. F., "Components in the Nutritive Value of Forages," Forage Economics-Quality, Am. Soc. Agron. Spec., Publ. 13, p. 47.

being made up of three main components, viz: 8/

$$\text{Nutrient Intake} = \begin{array}{c} \text{intake of} \\ \text{feed dry} \\ \text{matter} \end{array} \times \begin{array}{c} \text{digestibility} \\ \text{of feed} \\ \text{dry matter} \end{array} \times \begin{array}{c} \text{efficiency of} \\ \text{utilization of} \\ \text{digested nutrients} \end{array}$$

Both intake and utilization are related to digestibility and digestibility is related to many other factors, including the efficiency with which the forage digested is utilized. There can be significant differences in intake among forage species with the same level of digestibility, yet, the digestibility of a forage is often predicted in terms of its species and stage of maturity.^{9/}

For purposes of this analysis, the variables in the above relation can be reduced to three components that conveniently measure the nutritive content of forage to beef cattle; dry matter, digestible energy, and digestible protein.

The general approach used to calculate the monthly productivity and nutritive content of forage crops in Table 2 was (1) to estimate actual productivity of dry matter by months for forages grown alone and in mixtures, (2) to ascertain the "proper" stage of maturity, and (3) to obtain from published materials the nutritive composition of the forages for the selected stage of maturity.

Since cattle must satisfy their nutritional needs daily throughout the year, knowing only the total annual productivity of forages is of little value. Especially when the time of production is probably more important for forages produced for grazing, than total annual yield. Thus, one would prefer to have productivities of grazed forage crops throughout the year, on a monthly basis at least, and preferably on a bi-weekly basis. However, not a great deal of data applicable to Mississippi is available on monthly productivity, not to mention nutrient content by month. Most productivity data collected in Mississippi were recorded by clipping dates, but there is little consistency in dates between years, locations, or crops. Furthermore, the first clipping is usually made after the forage obtains some given height, or stage of maturity, and often the growth up until the first clipping occurs over two or more months. Attempts to allocate the growth to the appropriate time period presents a difficult problem and can result in biased data. Monthly productivities of forage crops shown in Table 2 were estimated primarily from clipping data obtained over a number of years by the Agronomy Department at Mississippi State University.

The procedure used to compute energy and protein consists basically of (1) estimating dry matter production per acre by month, and (2) applying NRC conversion factors to derive energy and protein content. There are some problems associated with using the NRC data on composition of feeds. For a given forage, DE/kg and percent digestible protein can vary tremendously depending

8/Ibid., p. 48

9/Ibid., p. 49

on stage of maturity. Since the NRC tables include nutritional data for various stages of maturity, as well as for different methods of harvesting, one has the problem of selecting the proper table. For example, composition of fresh alfalfa fed green is shown for ten different stages of maturity, where DE/kg ranges from 2,734 for immature plants to 2,601 for mature plants. Percent digestible protein varies from 19.1 to 13.2 for the same range in stage of maturity.

Results of Analysis

The data on nutritive requirements of beef cattle (Table 1), and productivity and nutritive content of forages (Tables 2 and 3), were incorporated in the linear programming model along with cost and other appropriate data to determine a profit maximizing cow-calf system for a typical 500 acre Brown Loam area farm. The forage program obtained was believed to be too optimistic by some of my colleagues, mainly because the level of protein shown in Table 1 was too low. After increasing the protein requirements shown in Table 1 by 25 percent, the profit maximizing system summarized in Tables 4 and 5 was obtained. The profit maximizing system, which satisfies the minimum requirements shown in Table 1, consists of 149 acres of coastal, 92 acres of coastal overseeded annually with a suitable legume (or mixture such as red and crimson clover), 131 acres of fescue-regal clover, 45 acres ryegrass double-cropped with sorghum-sudan, and 83 acres corn silage. The solution indicates that all forages would be grazed continuously, except for May, June, and July, when surplus production from varying acreages of these crops would be removed as hay. The months in which the hay and silage would be fed, and the megacalories of energy supplied, are shown in Table 5. Protein is not shown, however, minimum protein requirements were more than satisfied. That is to say, energy was the critical restraint.

While the results may appear to be overly optimistic, they can be defended to the extent that input data used can be defended. While nothing has been said about costs, I might point out that all fixed and variable costs were accounted for, including annual cost of producing, harvesting, storing and feeding hay and silage.

The results of this analysis has some implications of interest to those who are interested in achieving greater efficiency in forage production and utilization. First of all, the importance of legumes in the profit maximizing system should be noted. Out of four crops produced for grazing, two include legumes; fescue-white clover and coastal over-seeded annually with legume. Secondly, the months in which energy is most critical, as indicated by the linear programming model, are August and September. This suggests that we need a forage crop that has relatively high production in these months, or to make hay or silage available in these months. Third, more cooperative work is needed between agronomists, animal scientists and agricultural economists to obtain the kind of data needed for evaluating legumes and other forage crops in a total systems framework. And fourth, the analysis reveals that there is tremendous potential for increasing efficiency in the production and utilization of forages on beef cattle farms in the Southeast.

Table 1. Minimum Requirements of Digestible Energy (DE) and Digestible Protein (DP) and Maximum Dry Matter (DM) Intake for a Spring Calving Bull Unit, by Month.

<u>Month</u>	<u>MegaCal. DE</u>	<u>Lbs. DP</u>	<u>Lbs. DM</u>
J	18,626	703	24,335
F	18,894	805	22,049
M	22,010	949	25,239
A	22,291	893	26,786
M	23,835	928	28,959
J	23,593	912	28,720
J	24,894	962	30,254
A	23,670	912	30,908
S	17,916	663	28,262
O	16,981	614	25,428
N	16,752	604	23,401
D	<u>17,321</u>	<u>634</u>	<u>24,258</u>
Totals	246,783	9,579	318,599

Table 2. Estimated production per acre of dry matter (DM) digestible energy (DE) and digestible protein (DP) by month for selected forage crops, Brown Loum Area, Mississippi.

Forage	Item:	J	F	M	A	M	J	J	A	S	O	N	D	Total
Permanent Pasture:														
Fescue	DM	150	150	500	1,100	1,000	600	200	200	250	350	300	200	5,000
	DE	201	201	670	1,474	1,340	804	268	268	335	469	372	268	6,670
	DP	16	16	54	118	107	64	21	21	28	37	32	21	535
Fescue-white clover	DM	160	190	600	1,600	1,480	800	250	250	400	480	400	200	6,800
	DE	214	240	801	2,135	1,975	1,068	334	334	534	641	534	267	9,077
	DP	21	24	79	211	195	106	33	33	53	63	53	26	397
Dallis-white clover	DM	75	150	250	750	1,200	1,500	1,200	800	250	150	100	75	6,500
	DE	99	198	335	1,050	1,728	2,190	1,776	1,200	375	222	134	99	9,406
	DP	14	29	47	137	214	264	209	137	43	26	19	14	1,153
Coastal bermuda	DM				350	2,100	2,600	3,200	1,550	1,400	800			12,000
	DE				483	2,698	3,588	4,416	2,139	1,932	1,104			15,560
	DP				44	267	330	406	197	178	102			1,524
Common bermuda	DM				300	1,300	1,700	1,800	700	500	200			6,500
	DE				414	1,794	2,346	2,484	966	690	276			8,970
	DP				38	165	216	406	89	64	25			826
Bahiagrass	DM				800	1,000	1,200	1,400	1,400	500	200			6,500
	DE				848	1,060	1,272	1,484	1,484	530	212			6,690
	DP				30	37	44	52	52	18	7			240
Coastal-legume	DM		500	722	1,317	2,181	1,995	2,358	1,066	951	636			11,727
	DE		700	1,011	1,838	3,026	2,756	3,257	1,471	1,312	881			16,252
	DP		97	140	239	325	268	309	135	121	90			1,724
Coastal-ryegrass	DM	275	350	600	838	1,460	1,779	2,214	1,066	951	492	275	275	10,375
	DE	347	441	756	1,084	2,015	2,454	3,055	1,471	1,312	679	347	347	14,308
	DP	69	88	150	180	185	226	381	135	121	62	69	69	1,635

(Continued).

Table 2. Estimated production per acre of dry matter (DM) digestible energy (DE) and digestible protein (DP) by month for selected forage crops, Brown Loam Area, Mississippi. (Continued)

Forage	Item:	J	F	M	A	M	J	J	A	S	O	N	D	Total
Annuals:														
Pearl millet	DM						1,690	1,885	1,885	560	390			6,410
	DE						2,096	2,338	2,338	694	484			7,930
	DP						105	117	117	35	24			398
Sorghum-sudan	DM						2,500	2,800	2,800	1,000	600			9,700
	DE						2,650	2,968	2,968	1,060	636			10,282
	DP						176	199	199	71	43			688
Ryegrass	DM	500	700	1,200	1,200	550						550	550	5,300
	DE	693	882	1,512	1,512	693						693	693	6,678
	DP	138	175	300	300	138						138	138	1,327
Wheat	DM	600	700	1,200	1,100							750	650	5,000
	DE	876	1,022	1,752	1,606							1,095	949	7,300
	DP	137	160	275	252							172	149	1,145
Wheat-ryegrass	DM	600	700	1,200	1,200	550						750	650	5,650
	DE	816	953	1,633	1,633	748						1,021	885	7,609
	DP	144	168	288	288	132						180	156	1,346
Double crop annuals:														
Sorgh.-sudan & wheat-ryegrass	DM	600	700	1,200	1,200		2,500	2,800	2,800			750	650	13,200
	DE	816	953	1,633	1,633		2,650	2,968	2,968			1,021	885	15,527
	DP	144	168	288	288		176	199	199			180	156	1,798

Table 3. Annual Production Per Acre of Dry Matter, Digestible Energy and Digestible Protein from Selected Forage Crops, Brown Loam Area, Mississippi.

Type of Forage	Pounds Dry Matter	Dig. Eng. Per kg	MegaCal Dig. Eng.	Pct. Dig. Protein	Lbs. Dig. Protein
Grazed:					
Fescue	5,000	2,954	6,670	10.7	535
Fescue-Wh. clover	6,800	2,942	9,077	13.2	897
Dallis-Wh. clover	6,500	3,190	9,406	17.7	1,153
Coastal bermuda	12,000	3,042	16,560	12.7	1,524
Common bermuda	6,500	3,042	8,970	12.7	826
Bahiagrass	6,500	2,337	6,890	3.7	240
Coastal-Legume	11,527	3,054	16,252	13.6	1,724
Coastal-Ryegrass	10,575	2,983	14,308	15.5	1,639
Pearl millet	6,410	2,734	7,950	6.2	398
Sorghum-sudan	9,700	2,337	10,282	7.1	688
Ryegrass	5,300	2,778	6,678	25.0	1,327
Wheat	5,000	3,219	7,300	22.9	1,145
Wheat-ryegrass	5,650	3,000	7,689	24.0	1,356
Wheat-ryegrass--sorghum-sudan, Dbl. crop	13,200	2,593	15,527	13.6	1,798
Hay:					
Fescue	1,000 ^{a/}	2,734	1,240	6.0	60
Fescue-Wh. clover	1,000 ^{a/}	2,680	1,216	9.1	91
Dallis-Wh. clover	1,000 ^{a/}	2,548	1,156	9.0	90
Coastal bermuda	1,000 ^{a/}	1,896	860	4.8	48
Coastal-legume ^{b/}	1,000 ^{a/}	2,129	966	6.2	62
Sorghum-sudan ^{c/}	11,000	2,557	12,758	6.7	737
Johnsongrass ^{c/}	12,300	2,792	15,577	8.0	984
Alfalfa ^{c/}	11,990	2,629	14,298	15.2	1,822
Coastal bermuda ^{c/}	12,000	2,547	13,864	9.1	1,092
Silage:					
Corn	9,332 ^{d/}	2,950	12,487	4.1	383
Sorghum	11,999 ^{d/}	2,478	13,487	2.5	300
Concentrate:					
SBCM	90	3,704	151	50.3	45

^{a/} Harvested from pasture. Data are reported per 1,000 pounds dry matter because yields are to be determined from later analysis.

^{b/} Cut in May.

^{c/} Produced specifically for hay.

^{d/} Dry Matter per ton of green silage is 33 percent.

Table 4. Profit maximizing forage production system; spring calving cow-calf program, 1969-71 average prices for cattle and calves, 500 acre farm, 666 cow units, Brown Loan Area of Mississippi.

Type of forage	Unit	Number of units
Grazed forages:		
Coastal-bermuda	Acre	141
Coastal-legume	Acre	92
Fescue-clover	Acre	131
Ryegrass-sudan (Dbl. crop)	Acre	45
Grazed forages cut for hay:		
Coastal (May)	Acre	19
Coastal (June)	Acre	44
Coastal (July)	Acre	53
Coastal-legume (May)	Acre	92
Coastal-legume (July)	Acre	31
Sudan (June)	Acre	45
Sudan (July)	Acre	45
Fescue-clover (June)	Acre	131
Corn Silage	Acre	83
Net returns to operators labor, management and general overhead	Dollars	31,323

Table 5. Monthly requirements and sources of Digestible Energy in Megacalories for profit maximizing beef production system, for 666 cow-calf units, with all calves sold at weaning, Brown Loam Area of Mississippi.

	J	F	M	A	M	J	J	A	S	O	N	D
Energy requirements ^{a/}	496,322	503,492	586,526	594,017	635,166	628,721	663,386	630,764	477,430	452,513	446,411	461,574
Energy sources:												
Grazed forages:												
Coastal bermuda		64,065	92,529	168,218	71,823	376,042	376,486	423,709	318,072	287,291	164,166	
Coastal-legume		31,488	105,093	280,116	259,124	252,235	195,856	134,629	120,077	80,631		
Rescue-clover	28,077	36,907	43,104	73,860	73,860		43,821	43,821	70,062	84,100	70,062	35,031
Ryegrass-sudan (D&L crop)								134,242			46,179	40,028
Stored forages												
Coastal hay			277,261								131,933	132,409
Coastal-legume hay	410,498	364,835								123,616	141,796	
Corn silage											56,441	254,106
Sorgh. sudan hay	20,840		37,783									
Rescue-clover hay												
Total	496,322	503,492	586,526	594,017	635,166	628,721	663,386	630,764	477,430	452,513	446,411	461,574

^{a/} Represents 26.64 Bull units, or 666 cow units.

Converting Brush to Tall Fescue

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Eastern Oklahoma has an area of 4.5 million acres classified as the Ouachita Highland resource area. These lands are rough, rocky, and covered with brush. The major income from these lands is from cattle but it often takes 40 acres or more to support one cow.

In 1970 research was begun on the Sarkeys Foundation land in Hughes County. This is a 40" rainfall area in southeastern Oklahoma. The objective of these studies was to establish tall fescue following brush control. This is not new to many areas of southeastern United States but it is new to Oklahoma.

Four herbicide treatments were applied to 10 acre plots. Two replications were left in native grass and 2 replications were burned and seeded to fescue. This provided 80 acres of native grass to compare with 80 acres of fescue. The herbicide treatments were:

1. 2 lb/A of 2,4,5-T Low Volatile ester
2. 2 lb/A of 2,4,5-T plus 1 lb of picloram (both triethylamine)
3. 2 lb/A of 2,4,5-T (triethylamine) plus 1 lb/A dicamba
4. 1.5 lb/A of 2,4-D plus 1.5 lb/A of dichloroprop (both L.V. ester)

Herbicide treatments were applied by airplane on June 8, June 9, June 16, and June 17, 1970.

A controlled fire on September 29 was used to remove leaf litter and permit good soil-seed contact. Burning in early September would be preferred because the burn would also be harmful to the native grass (and broomsedge) and would reduce its growth rate the next spring. This would favor fescue establishment.

Fifteen pounds of tall fescue seed per acre was blended with a starter fertilizer of 12-33-20 and was applied by airplane on October 2. The germination of the seed was much lower than the 85% stated by the dealer (actually about 23%.) Small plot tests showed that more nitrogen was definitely needed. With good seed and proper fertility, these areas could be brought into full production within 1 year after starting.

The fescue was not grazed in the spring of 1971 but was fertilized in early September of 1971 with 51-51-51 and 70-0-0 was applied on February 23 for spring production. Grazing started on December 1. Total grazing with cows, some with calves at their side, up through April, 1972, was 94 cow days/A. Grazing is being continued at least through May with 70 cows in the pasture.

Total grazing for this first season has been reduced because the stand establishment is still incomplete. However, tall fescue is rapidly becoming established in these barren areas and the overall stand is becoming more complete except in the area which was cleared of timber to serve as a fire guard.

Nitrogen applications in the future will probably be in late August and again in February to get more economical use of fertilizer. P & K will be applied as needed.

The goal is one acre to support one cow for 6 months from December 1 until June 1. The system appears promising but several questions have not been answered. (1) Will fescue survive on shallow upland sites? (2) Will the brush respond with faster growth when fertilized, or will the active spring growth of the fertilized fescue provide severe moisture competition and slow the growth of the brush sprouts? (3) How can the sprouts be controlled? (4) How

soon and what method will be used to apply lime? (5) Will the system be economically feasible?

In early spring 1972, the growth of oak sprouts on the fescue area was about 50% of the oak sprout growth which occurred on the native grass area. It is possible that fescue competition will reduce the oak sprout growth rate, but this may make the sprouts more difficult to control with herbicides if they are not growing actively.

The system appears promising but many problems remain to be resolved.

Acknowledgement: These studies are made possible through funding by the Sarkeys Foundation, Oklahoma City.

Status of Tall Fescue Research in Arkansas

A. E. Spooner
University of Arkansas

Tall fescue is the most important cool season grass used in pastures in Arkansas. There are about 1,000,000 acres of fescue in the State at present and the acreage is increasing at a rapid rate each year. It is predicted that the acreage of tall fescue will surpass that of bermudagrass in the near future.

Our research with tall fescue is divided into two parts: (1) the testing of varieties for adaptation, yield, fertilizer requirements and quality as measured by the artificial rumen and mineral analyses, and (2) grazing data on productive capacity, fertilizer rates, deferred grazing and the inter-seeding of fescue in bermudagrass sod.

Four varieties of tall fescue have been tested in Arkansas. They are: Kentucky 31, Kenwell, Fawn and Goar. All four varieties are well adapted to the entire State. Yields were about the same for Ky. 31, Fawn, and Goar but Kenwell yielded about 0.25-0.40 ton less than the other three varieties. There was some problem with leaf diseases on Fawn during the fall season. No serious yield losses were noted due to the disease. There were no differences noted in dry matter digestibility or mineral content between the four varieties.

Tall fescue can be grazed most of the year in North Arkansas. This is especially true where good fertilization practices are followed. We are recommending that two-thirds of the allotted pasture land in Arkansas be seeded to tall fescue and one-third to bermudagrass. We recommend the seeding of white clover with all fescue. We are deferring one half of our fescue from June 1 to December 20 for our cow herds. This deferred fescue is grazed from December 20 to March 20, which is our breeding season, and again in late April and May if forage is available. The other fescue is grazed in the fall and spring. The bermudagrass is grazed during the summer months.

We have completed 8 years of research on the interseeding of tall fescue-white clover in a bermudagrass sod. This practice works well provided you manage your fertilization and grazing management to keep the desired species balance. We use this species combination for growing replacement heifers on a year-round basis.

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Fescuegrass in Louisiana

C. L. Mondart, Jr.
Louisiana State University

Fescuegrass is the leading perennial winter grass for the poorly drained, heavy clay soils in Louisiana. It is also adapted to the medium textured soils, especially in the areas with adequate rainfall during the late spring and summer months. It is grown in these adapted areas alone, and in combination with various legumes for grazing. White clover and red clover are the legumes used most widely in combination with fescuegrass. Most of the acreage of fescuegrass in Louisiana is located on the poorly drained, heavy clay soils.

In 1970, the Soil Conservation Service estimated the acreage of fescuegrass in Louisiana at approximately 64,000 acres. Almost half of this acreage is located in two parishes. In 1963 and 1965, the acreages were estimated at 62,000 and 66,000, respectively. This indicates very little change in acreage of fescuegrass in Louisiana during the past several years.

There has been very little pasture research conducted with fescue in Louisiana. At the present time, there are no research projects involving fescue, with the exception of a few varietal trials.

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V. H. Watson, C. Y. Ward, M. C. Futrell, D. R. Farnell, and W. E. Poe ^{1/}

Tall fescue (Festuca arundinacea Shreb) is the most important cool season perennial grass in Mississippi. There were approximately 121,500 hectares (300,000 acres) of tall fescue used during 1971. Most of the hectareage is utilized in beef cow-calf programs, and in dairy programs for maintenance of dry cows. Recent surveys show that it is one of three grasses increasing in hectareage in the state.

Our research efforts with tall fescue have generally been directed toward (a) nitrogen fertilization, (b) management requirements for legume compatibility, (c) seed production, (d) stockpiling, and (e) fescue toxicosis.

In general, seasonal and total dry matter yields can be regulated by the time and rate of nitrogen application. Economical response to N is between 134 and 201 kg/ha (120 and 180 lb/acre), and dry matter production of tall fescue plus white clover is equal to the yield obtained with 168 kg/ha (150 lb/acre) of N on tall fescue alone.

Studies on tall fescue-white clover compatibility show that excellent yields, desirable botanical composition, and better persistence can be obtained if tall fescue is planted in 50 cm (20 inch) wide rows and grazed to a 6.5 cm (3 inch) stubble. Broadcast plantings of tall fescue and white clover are much more variable, and are more dependant on uniform distribution of rainfall than row plantings.

Seed yields and seed quality of tall fescue are increased as N increases from 0 to 134 kg/ha (0 to 120 lb/acre). Good seed yields and seed quality are obtained from tall fescue swards if grazing is terminated by March 15. If grazing is continued past April 30, very little seed is produced.

Reports of fescue toxicosis are distributed throughout the state, and recent research efforts indicate that the fungus, Aspergillus terreus, may be involved in the syndrome^{2/}. Rumen samples from cows showing symptoms of fescue toxicosis contain high populations of A. terreus, and the fungus can be controlled with regular treatment with thiabendazole. Population of A. terreus in tall fescue also increase as the level of nitrogen fertilizer increases.

^{1/} Contribution of the Department of Agronomy, Plant Pathology and Weed Science, Veterinary Science, and Biochemistry, Mississippi Agricultural and Forestry Experiment Station.

^{2/} Farnell, D. R. and M. C. Futrell. 1972. Studies on the etiology and control of fescue toxicosis. Annual Meeting of the Animal Disease Res. Workers in the Southern States. College Station, Texas, March 16, 1972.

Tall Fescue Research in Alabama

C. S. Hoveland
Auburn University

Tall fescue is grown on over 800,000 acres in Alabama. Most of this acreage is in the northern third of the State but in recent years tall fescue has been planted widely in the Black Belt and to a lesser extent south to the Gulf. Previous adaptation trials showed that Ky-31 tall fescue forage yields of 3-1/2 tons per acre were obtained under good fertilization in northern Alabama as compared to less than half that in the southern part of the State.

Present research on tall fescue is concerned with five aspects:

- (1) Breeding for fall and winter growth, rust and leaf spot resistance (C. D. Berry).

Ky-31 tall fescue is too winter dormant for the lower south and efforts are being made to breed more winter-productive types. Rust is an increasingly serious problem on present tall fescue varieties. A large screening program has made progress in identifying plants with apparent rust resistance.

- (2) Nitrogen fertilizer rate and time of application (C. C. King).

Rates of up to 300 lb/A applied at different times of the year are being used along with no rest, summer rest, fall rest, and summer and fall rest to measure seasonal forage production and persistence. Acid detergent lignin and fiber are being determined.

- (3) Summer rest, nitrogen rates, stubble height, and carbohydrate reserves (C. S. Hoveland).

The value of summer rest and stubble height on autumn and winter forage production is being studied. The relationship of N rate and summer rest on seasonal forage production, stands, and carbohydrate reserves is being examined in other experiments.

- (4) Methods of establishment (C. S. Hoveland).

Tall fescue furnishes very little forage during the establishment year. Experiments in progress over the last 3 years have studied the effect of planting rye and tall fescue together in various combinations.

- (5) Grazing trials (E. M. Evans, C. C. King, and C. S. Hoveland).

Tall fescue with or without white clover has been compared using steers. Wintering of beef brood cows on tall fescue grazing is being compared with other systems. Performance of yearling steers on an association of Ky 31 fescue-dallisgrass-Regal ladino is being compared to dallisgrass-Regal ladino with and without supplemental feed while on pasture.

STATUS OF TALL FESCUE IN FLORIDA

James T. Johnson
University of Florida

Tall fescue is not an important pasture grass in Florida. Less than 1000 acres of fescue pasture are currently in production. In Florida, tall fescue acts as a cool season perennial, furnishing grazing from September through April. Maximum production in late fall and early spring. Fescue growth is very slow during our hot and humid summer months.

Early research throughout Florida indicated that fescue was poorly adapted to either the sandy, well drained soils or the acid, poorly drained flatwoods soils in the central and southern areas of the state. Weed competition and failure of plantings to survive dry fall weather or excess water during the summer rainy season were the primary problems. However, research in the northwestern area of the state indicated that fescue had some potential in winter grazing programs. The soils in this area along the Alabama border range from sandy loams to loamy sands in texture and are more productive than most Florida soils.

Langford and Hutton (2) obtained 309 pounds of liveweight gain per acre when Kentucky 31 tall fescue was grazed from mid-October to late April at the Agricultural Research Center at Jay. In later research (1) over a three year period, Kentucky 31 tall fescue pastures carried an acreage of 1.39 stocker steers per acre for 221 days. Liveweight gains per animal averaged 1.06 pounds per day and gains per acre averaged 323 pounds. Although the three year average results were quite impressive, in the third year of the study average daily gains per animal were only 0.70 pounds per day and gains per acre were down to 241 pounds. Declining production experienced with older stands was cited as a major drawback to fescue utilization in Florida.

The economics of using tall fescue for wintering brood cows is questionable when the fertility requirements for satisfactory growth are considered. Kentucky 31 tall fescue fertilized with 400 pounds of nitrogen and 70 pounds each of P_2O_5 and K_2O per acre, yielded about 2.5 tons of dry matter per acre (1). In contrast, rye, which is productive from December through April under our conditions should produce an equivalent amount of high quality forage with 120 pounds of nitrogen per acre, representing a considerable savings in fertilization costs.

In recent years research emphasis in the northwest area of Florida has shifted from tall fescue to the annual winter grasses, rye, wheat and oats, and the annual legumes, crimson and arrowleaf clover for use in stocker programs and in forage programs for wintering brood herds. These crops produce well with less applied fertilizer and may be double-cropped with summer growing species for more efficient land utilization.

Research results have been encouraging. Stocker steers grazing a rye-ryegrass-Yuchi arrowleaf clover combination gained 2.05 pounds per day over a 148 day grazing season in 1970-71 at Jay (3). The pastures carried 1.76 steers per acre per day and produced 535 pounds of liveweight gain per acre.

Based on present research information it is apparent that tested cultivars of tall fescue, primarily Kentucky 31 and Alta, do not have a bright future in Florida forage programs. If cultivars better adapted to lower south conditions are developed this situation could very well change.

- (1) Dunavin, L. S. Jr. 1961. Another look at tall fescue for northwest Florida. Soil and Crop Sci. Soc. Proc. 21:128-136.
- (2) Langford, W. R. and C. E. Hutton. 1953. Florida Agr. Exp. Sta. Ann. Rept. 338-339.
- (3) Bertrand, J. E. 1971. (Unpublished data).

R. H. Brown
University of Georgia

Research with fescue is being carried out at several locations in the State. The purpose of this summary is to give an idea of the scope of the fescue research. The research deals mostly with management, adaptation and utilization.

At the Mountain Station, Blairsville, interseeding of Ky 31 fescue into Midland bermudagrass is being studied. Fescue row spacings of 8, 16 and 24 inches have been tried at a high N level, 450 lb/acre per year. Fescue persisted best with an 8 in. spacing. In a second study Ky 31 fescue was grown in a mixture with Midland bermuda and cut at heights of 1, 2, 3, and 4 inches. Fescue persisted best when the mixture was cut at 2 inches.

In a study of fescue - white clover production it was found that white clover increased forage yields compared to N-fertilized fescue when applied N was less than 300-400 lb/ac. In a separate study of tillering in fescue at the Mountain Station it was found that mowing in October stimulated tillering during the following 30 days but that mowing in January did not affect tillering. Studies at Athens have shown that plants continue to tiller during summer if cut frequently. Tillering began within 2 weeks after defoliation in summer, but after defoliation in winter 2 months were required before tillering commenced.

In southwest Georgia at the Americus Plant Materials Center, several strains of fescue from a world collection are being studied for persistence under south Georgia conditions. Some strains have persisted well during the summer whereas others have died out. Those clones which have survived several years appear to maintain green color much better in hot months. Seed production is a problem on some of the hardy strains, but not on others.

Utilization of fescue by grazing is receiving a good deal of study. At the U.S.D.A. Southern Piedmont Station at Watkinsville, Ga., animal health problems associated with fescue are being investigated. Experiments with poultry litter fertilization are being conducted to study problems of fat necrosis which appear to be associated with poultry litter on fescue. Grazing experiments are being conducted at the Piedmont Experiment Station at Eatonton, Ga., to evaluate fescue, bermudagrass and fescue-bermudagrass mixtures for cow-calf herds. Records of available forage as well as beef production are being kept in an effort to match forage production to animal requirements.

Experimental Units involved in fescue research --

Mountain Experiment Station - Blairsville
USDA - Southern Piedmont Station - Watkinsville
College Experiment Station - Athens
Piedmont Experiment Station - Eatonton
SCS Plant Materials Center - Americus

Abstract

Status of Tall Fescue Research in South Carolina

M. W. Jutras
Clemson University

Tall fescue is widely distributed in South Carolina, representing more than 270,000 acres used as improved pasture, plus much more as unimproved pasture, as a hay and soil-holding crop, as a turf grass, and as a wild plant. Although mainly concentrated in the Piedmont, it is found in all parts of the state. This important forage crop has not received much research attention except in the last 10 years or so. This research has tended to be practical and farm oriented rather than "basic"

We've found that drilling the seed one inch deep, in 8" rows for pure grass stands and in 18" rows for fescue-clover stands is superior to broadcast. Studies have shown that little root or top growth occurs below 10C (50F) or above 32C (90F). Thus, planting fescue in the Clemson area before or after the month of September usually results in failure. In addition to the foregoing stand establishment studies, we've increased seedling vigor by applying 280 kg/ha. (250 lbs/a.) 6-12-12 in the band with the seed; higher rates did not improve stand or dry matter yields. Further, drilling oats in the newly-prepared seedbed at the rate of 2.3 hl/ha (2 bu/a) allowed grazing in 1 to 1 1/2 months instead of the usual 6 months delay. Further, the heavy clover stand the following spring is diluted, and throughout this period, soil and water is conserved by the actively growing oats.

A second interseeding test involved fescue as one of 19 species top-seeded into a Coastal sod 6 1/2 years ago, in all possible combinations. Preferential grazing of the strong fescue-Coastal combination has taken place, increasing the effective grazing period of the bermuda.

Two major research projects have involved studies of combinations of forages for year-round grazing. Animals either were assigned to particular grazing lots at specified times or were allowed free-choice grazing of 2 or more lots. Fescue-Ladino clover was compared to pure fescue for growing replacement beef heifers; these forages were grazed whenever forage was available, then the heifers were placed on Coastal in summer or stockpiled fescue in winter when the primary forages were dormant. Good results were obtained with this particular combination, with the fescue-clover providing better weight gains and N fertilization savings compared to fescue alone, but the clover-grass would probably have to be re-established every 5 years or so.

From here, we continue to be interested in combinations for year-round grazing, and hope that a fescue cultivar is forthcoming that will have improved palatability and digestibility and retain Ky. 31's tenacity and wide adaptability.

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W. W. Woodhouse, Jr.
North Carolina State University

In a 5-year trial on a Cecil clay loam involving 20 treatment combinations average dry matter production ranged from a low of 2 tons (from 50 lbs N September 1) to a high of nearly 4 tons (from 100 N March 1, 100 N April 15, and 50 N September 15).

Total production was essentially identical from 100 N applied either February 15, March 1, March 15, or April 15. Early spring growth was definitely encouraged by the early application.

The "summer slump", (July-August) was little affected by either of 10 combinations of timing of N applications. However, treatments that stimulated high spring production did not inhibit fall production, where late summer N was applied.

Response, in terms of fall growth, from N applied in late summer was only slightly lower than spring response to N applied in the spring.

Table 1. Effect of time and amount of nitrogen application and use of potash on growth of tall fescue.

No.	Treatments											Yield/lb/A	
	N/acre - annually												
	Feb 15	Mar 1	Mar 15	Apr 15	May 15	Aug 15	Sept 1	Sept 15	Oct 1	Oct 15	Total	1971	1967-71
1. NPK	100							50			150	5636	5840
2. "		100						50			150	5339	5632
3. "			100					50			150	5272	5709
4. "				100				50			150	5619	6007
5. NPK		50		50				50			150	5751	6039
6. "		50			50			50			150	5522	5820
7. "		100		50				50			200	6588	6831
8. "		100		100				50			250	7134	7526
9. NPK		50		50		50					150	6582	6607
10. "		50		50			50				150	6503	6545
11. "		50		50					50		150	5530	6284
12. "		50		50						50	150	4886	5658
13. "		50		50							100	4894	5335
14. "		50		50			50		50		200	6538	7046
15. "		50		50				100			200	6340	6982
16. NP		50		50				50			150	5870	6355
17. NPK							50				50	4152	4103
18. "							50		50		100	4542	5017
19. "							100				100	4646	5166
20. "							100		100		200	5879	6757

245
Evaluation of Tall Fescue Alone and in Mixture with Ladino Clover or
Grazed in a System with Coastal Bermudagrass

J. C. Burns and Lemuel Goode
North Carolina State University

The characteristic midsummer reduction in growth of tall fescue requires the availability of supplemental feed if adequate animal gains are to be obtained. This can be achieved either by supplying stored feed or grazing tall fescue in combination with a warm season species. The growing season of coastal bermudagrass, its longevity and high yield makes it a likely candidate.

Grazing trials have been conducted with cow-calf testers (data in press) showing the animal performance (quality aspect) from a tall fescue (TF) compared with a ladino clover-tall fescue mixture (L-TF) and when each is grazed in combination with coastal bermudagrass (CB). During the spring (until May 31) calves grazing L-TF gained 95.5 lb/head compared to 82.2 lb/head from TF. From May 31 until mid-September calves grazing L-TF gained 176 lb/head compared to 123.7 lb from TF. However, the inclusion of CB with TF (TF + CB) increased calf gains to 150.6 lb/head. Including CB with L-TF (L-TF + CB) reduced calf gains to 161.2 lb/head. The significance of these data are that CB can be used in a cow-calf enterprise during midsummer without appreciably lowering gain/calf.

A study is currently being conducted to determine the animal response/acre (quantity aspect) of a pure grass system (TF + CB). Two levels of nitrogen fertilization (120 and 240 lb/A), each with three stocking rates and a rotational put and take management feature are being evaluated.

Preliminary data from the first year of this study appear quite favorable. Calf daily gains and the respective stocking rates (computed as cow-calf units/A (1357 lb) are as follows: 1.77 (3.6); 1.58 (4.5) and 1.20 (5.1). The performance at both the 3.6 and 4.5 cow-calf units/A rate agree well with (actually greater than) gains obtained in the former study. Additional data are needed to better evaluate the animal response/acre.

Table 1. Summary of some nutritional components of a spring, midsummer, and fall harvest of tall fescue for eight cutting managements, 1969 and 1970.
(Note IVDMD analyses are from 1 replication only.)

Treatment	Year	Harvest	Date	NDF (%)	ADF (%)	Lignin (%)	Ash (%)	Cellulose (%)	IVDMD (%)
4-1/2 - 3-1/2	1969	4	4/24	42.5	24.2	2.61	0.77	20.8	78.9
		10	8/12	51.7	29.3	4.54	0.66	24.1	68.3
		12	10/3	42.2	24.2	2.49	0.92	20.9	79.1
	1970	3	4/23	47.1	25.8	2.39	0.82	22.6	78.6
		10	8/13	50.1	27.4	2.50	0.88	24.0	73.9
		13	10/28	38.9	20.8	2.12	0.30	18.4	73.7
	1969	1	4/24	42.5	24.1	2.50	0.63	21.0	78.5
		3	8/27	54.9	31.0	5.02	1.25	24.6	66.0
		4	10/3	40.2	22.9	2.20	0.96	19.7	80.1
12 - 2	1970	1	5/5	56.0	31.7	4.53	0.56	26.6	68.4
		2	8/26	58.6	32.0	4.34	0.66	27.0	58.7
		3	12/1	40.3	21.6	1.93	0.89	18.8	80.0
	1969	1	4/21	41.8	23.8	2.83	0.57	20.4	80.9
		4	8/12	51.7	30.5	5.97	1.36	23.2	69.2
		5	10/3	40.3	23.0	2.73	0.86	19.4	79.2
	1970	1	4/23	46.2	26.2	2.88	1.20	22.5	76.9
		2	8/13	50.2	27.7	3.70	0.72	23.3	63.5
		4	10/28	44.3	24.6	3.46	0.64	20.5	68.1
6 - 2	1969	3	4/21	43.2	22.9	2.50	0.64	19.7	79.5
		9	8/12	50.7	29.2	5.50	1.08	22.6	70.6
		11	10/3	38.5	21.5	2.09	0.81	18.6	81.4
	1970	3	4/23	48.8	26.7	2.60	1.09	23.0	77.2
		9	8/13	49.8	27.3	2.65	0.80	23.8	72.2
		11	10/6	44.6	24.7	3.77	0.98	19.9	68.6

245
Changes in Quality and Chemical Constituents of Tall Fescue
throughout the Growing Season at Various Degrees of Defoliation

J. C. Burns and Douglas S. Chamblee
[North Carolina State University]

Preliminary results from a defoliation study involving eight defoliations regimes (ranging from cutting at 12" back to 2" to cutting at 3" back to 2") with tall fescue indicate that cell wall constituents generally increase in midsummer (August) compared to an April or October harvest (Table 1). Consequently, the acid fiber portion also increases with lignin frequently increasing by 100%. Associated with this increase in cell walls is an approximate 10 percentage unit decrease in IVDMD. Although only one replication for IVDMD has been completed, it is of interest to note the generally high values obtained for most defoliation regimes. Only for the treatment (12" back to 2") were levels below 60% IVDMD. Except for extreme defoliation treatments, cutting frequency may have a greater influence on dry matter yield than on nutritive value.

As noted in Table 2, the highest total yields were obtained from the hay-type cutting managements. A comparison of the simulated grazing-type management (total height before cutting being no more than 6") shows that a stubble height of 2" was much more productive than the 3-1/2" stubble height.

Table 2. Effect of height and frequency of harvest on total yields of tall fescue grown in pure stand.

Height *	Tall Fescue Defoliation Study 1966-71
	Cut all season
12 - 3-1/2	7278
6 - 3-1/2	5060
4-1/2 - 3-1/2	5035
12 - 2	7868
6 - 2	6753
4 - 2	6111
3 - 2	6042
3 - 1-1/2	5509

Seeded September 1, 1965.

Annual fertilization:

240 pounds N/A (100 Feb. 15, 60 April 1, 80 Sept. 7) plus 800 pounds/A
0-9-27.

* For example, 3-2 was cut back to a stubble height of 2" each time growth reached 3". Treatment 3 - 2 was cut about 20 times annually.
(12-2 treatment cut last on November 5, 1971, yielded 1890 pounds/A on November 5.)

Status of Tall Fescue Research in Kentucky

T. H. Taylor and W. C. Templeton
University of Kentucky

Tall fescue in Kentucky increased from a few thousand acres in 1945 when 'Kentucky 31' was released as a variety to approximately 6,000,000 acres in 1971. From 1962 to 1972, all cattle increased from 2,242,000 to 2,803,000 head, an increase of 561,000. Beef brood cows accounted for 508,000 of this increase. Kentucky farmers in 1971 renovated and seeded to legumes approximately 750,000 acres of grasslands.

Over the years our greatest effort has gone into breeding programs with the hope of developing a variety superior to 'Kentucky 31'. 'Kenhy', a new experimental variety ($2n=42$ chromosomes) derived from unstable $2n=56$ chromosome ryegrass-tall fescue ampheloid, is presently being intensively evaluated in small plot experiments at Kentucky and 20 other States. No experimental grazing trials are being conducted by the Kentucky Station at this time. However, forage extension specialists have several farmer grazing trials. If 'Kenhy' proves to be a superior variety, it will probably be released sometime in 1974.

Other active lines of investigation are: (1) Physiologic and genetic studies of alkaloids in *Festuca* spp., *Lolium* spp. and hybrids. Results to date show that heritability of peroline to be quite high, r values being 0.95 or higher. (2) Quantity and quality of late summer and autumn produced tall fescue herbage for winter grazing. Results over a 2-year period show that with adequate fertilization approximately 2 tons of herbage may be accumulated in the field from August 15 to December 1. Nutritive value indexes of the standing crop were 69, 67, 65, 48, 43, 37, and 38 on the first of October, November, December, January, February, March and April, respectively. Crude protein of the herbage varied from 15.5 to 10.6% from October 1 to April 1. Even at its lowest point, January to March period, the herbage was above the NRC requirements for non-lactating beef brood cows. (3) Beef brood cow-calf study comparing tall fescue-clover vs Kentucky bluegrass-clover pastures. Results over a 2-year period show that calves without creep are higher gaining on bluegrass-clover than are those on fescue-clover pastures. Creep-fed calves were similar in gains on the two type pastures. (4) Performance of yearling steers on tall fescue-Kentucky bluegrass plus N vs tall fescue-bluegrass-alfalfa pastures. Tall fescue dominates the grass component of these pastures. In 1972 we have for the first time adequate stands of alfalfa to make valid comparisons. Finally, (5) establishment trials of birdsfoot trefoil in tall fescue sod growing on rough hill land were initiated in the spring of 1972.

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Research on Tall Fescue in Tennessee

John H. Reynolds
University of Tennessee

An estimated 3 million acres of tall fescue pastures (out of a total of 5 million acres of permanent pasture) are grown in Tennessee according to Mr. Burns, Forage Extension Specialist. A large part of this fescue acreage also contains white clover or annual lespedeza.

Dr. Fribourg is carrying out some clipping management experiments with tall fescue seeded in bermudagrass sods. He included tall fescue in a study of some cool-season annuals overseeded in bermudagrass sods at Jackson. Fescue yielded slightly less in Midland sods than in Common sods. Fescue has continued to extend the forage production season by 2 to 3 months in bermudagrass sods for 5 years. Other more detailed clipping experiments are presently underway at Jackson. At Knoxville, extremely close clipping treatments on fescue sods are being compared for the second year. During the first year, there were few differences in stand density or in estimated digestibility of the forage.

Dr. Barth is cooperating in quality evaluation of clipped fescue and is also following seasonal changes in chemical composition and digestibility of fescue pastures. Dr. Barth and Dr. Constantin at Oak Ridge are cooperating in estimating dry matter digestibility, crude protein content, crude fiber content, and yield in a large number of fescue plants grown from irradiated seed. The relationships of visible leaf characteristics to these forage quality estimates are being determined. Dr. McLaren has been conducting grazing experiments on tall fescue pastures at Springfield. When Kentucky 31 and Kenwell fescues were grown with ladino clover, no difference was found between the two varieties in animal performance or in clover percentage in the pastures. He is presently comparing renovation of fescue pastures with ladino clover, renovation with a mixture of ladino clover, red clover, and Kobe lespedeza, nitrogen fertilization of unrenovated fescue, and unrenovated fescue not fertilized with nitrogen. Calf daily gains were highest with the 3-legume renovation, next highest with ladino renovation, and lowest

with unrenovated fescue treatments. Dr. Montgomery and Dr. Barth are comparing fescue hay qualith when cut at three growth stages in the spring. Evaluations will include daily gain of heifers, digestibility by sheep, chemical composition, and in vitro digestibility.

★★

A Short History of Kentucky 31 Fescue

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Kentucky 31 fescue is an ecotype of tall fescue (Festuca arundinacea Schreb.) that developed on the mountain farm of William O. Suiter in Menifee County, Kentucky, from the natural screening of a population of the species that was on the farm when he purchased it in 1887. It is likely that the original seed was purchased from a seedsman in Virginia. The grass was brought to my attention in 1931 by W. K. Wells because he and other local farmers held it in high regard for pasture and erosion control.

The grass was sown on the Experiment Station farm at Lexington in the spring of 1932 for general evaluation. Although its annual yields of herbage from these seedings were not significantly different from those of Kentucky bluegrass and orchardgrass, the ecotype was believed to possess other qualities of a good pasture grass; longevity, tough sod, deep root penetration, and high production of herbage in spring, autumn and early winter. Its relative pasture value was

1 believed to be satisfactory because Mr. Suiter, Mr. Wells and neigh-
2 boring farmers had found their livestock to thrive on it. Consequently,
3 it was decided that the ecotype should be evaluated for its pasture
4 value in Kentucky outside the Central Bluegrass Region. Therefore
5 plots were seeded to the grass in 1938 and 1939 by J.F. Freman of the
6 Agronomy Department on the Experiment Station's established experimen-
7 tal soil fields in different soil areas of Kentucky. Seed for test
8 demonstrations was distributed to farmers in different parts of
9 Kentucky in 1939 and subsequently by W.C. Johnstone, Field Agent in
10 Agronomy. In both kinds of seedings the ecotype showed that it was
11 well adapted to all parts of Kentucky and that it was more productive
12 of herbage on most soils outside the Central Bluegrass Region than
13 other commonly grown cool-season grasses. Farmers soon pronounced it
14 a good pasture grass, excellent for improving soil tilth, and effective
15 for controlling erosion.

16 It is impossible to fix the year in which Kentucky 31 fescue was
17 named and released in Kentucky as a cultivar because it may be said to
18 have had a gradual release after 1942, the year in which it was
19 recommended for trial seeding on a field scale. Perhaps the actual
20 official release may be considered to have occurred in 1945 when it
21 was approved as a cultivar eligible for certification in Kentucky's
22 seed certification program.

23 The College of Agriculture of the University of Kentucky apparently
24 issued its first official statement on Kentucky 31 fescue in its
25 Agricultural Extension Circular 390 (1942). A second statement appeared
26 in the Fifty-sixth Annual Report (1943) of the Kentucky Agricultural
27 Experiment Station. Subsequent statements appeared in most of the
Annual Reports. A brief history of the cultivar appeared in University
of Kentucky Agricultural Extension Circular 497 (1952) which also
considered its culture and use. A Progress Report in Kentucky Farm
and Home Science, Vol. 6, No. 1 (1960) expressed the official judgement
of the Kentucky Agricultural Experiment Station regarding the cultivar
at that time.

28 The amount of certified seed and uncertified seed of Kentucky 31
29 fescue produced annually in Kentucky reflects to a degree the

1 importance of the cultivar over the years. In 1946 - the first year
2 in which its seed was certified - 17,496 pounds of certified seed were
3 produced on 179 acres according to records of the Kentucky Seed Im-
4 provement Association. Production of certified seed increased rapidly
5 but not uniformly to 11,681,261 pounds in 1952, harvested from 49,485
6 acres. Amounts of certified seed then declined gradually but unevenly
7 to an annual average of 1,629,224 pounds from an annual average of
8 4,452 acres in the period 1966-1970. The total amount of certified
9 seed produced in Kentucky from 1946 to 1970 was 78,943,273 pounds.

10 Combined certified and uncertified seed of tall fescue in amounts
11 of record was first produced in Kentucky in 1948 according to the
12 Statistical Reporting Service, Crops Reporting Board, United States
13 Department of Agriculture. In that year production amounted to
14 3,000,000 pounds of clean seed. From 1948 to 1970 the total production
15 has been 288,070,000 pounds. It is estimated that 99% of this amount
16 was certified Kentucky 31 seed or uncertified seed of Kentucky 31
17 parentage.

18 The acreage of pure and mixed stands of tall fescue in Kentucky
19 of Kentucky 31 parentage is estimated to be about 6,000,000 acres.

20 Kentucky 31 fescue was moved early into other Southeastern states
21 upon the recommendation and with the assistance of many individuals,
22 who, for the most part, were attached to state and federal agencies,
23 notably the Soil Conservation Service, and rather soon indicated that
24 it was best adapted in Eastern United States to the area roughly
25 between the latitudes of Indianapolis, Indiana and Macon, Georgia and
26 the meridian of west Missouri and the eastern edge of the Piedmont
27 area. Within these boundaries it is estimated that the acreage of tall
fescue of Kentucky 31 parentage in pure and mixed stands is about
17,500,000 acres, the largest acreages being in Kentucky, Missouri and
Tennessee. Seed of Kentucky 31 parentage produced in this area in
1970 is estimated to have accumulated to 55,527,000 and the total
estimated amount of such seed produced from 1948 to 1970 is 645,800,000
pounds.

Kentucky 31 fescue is included in the list of cultivars of the
OECD Scheme for the Varietal Certification of Herbage Seeds Moving in

1 International Trade, Edition 1970. Substantial amounts of seed of
2 the cultivar has moved under the Scheme to many other countries.

3 Although Kentucky 31 fescue has been and is of tremendous value
4 for forage, seed and erosion control within the area in east United
5 States where it is best adapted, it is impossible to estimate that
6 value with confidence. In Kentucky the cultivar's contribution to
7 erosion control has been invaluable. Its forage - mainly pasture -
8 value can be indicated by the fact that it has been a major factor in
9 making it possible for Kentucky farmers to increase their cattle
10 numbers from 1,608,000 in 1950 to 2,859,000 in 1971.

11 **

Forage Management and Utilization in Relation to Climate
(increasing rainfall and temperature).

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The Hawaiian Islands are a unique laboratory to study plant-animal-environment interaction. Hawaii is comprised of six major volcanic islands approximately 20° north latitude and 2,700 miles from the nearest continent. North-east tradewinds prevail and, combined with topography and altitude, provide environmental conditions ranging from wet tropical to dry tropical and desert, to temperate and even alpine. The total land area is approximately 4.1 million acres of which 1.8 million acres are used in livestock production.

With the wide range in soil, temperature, rainfall, and forage types, live-stock management for proper forage utilization and animal production become quite complex. Most cattle ranchers have rangelands that move through several vegetation zones (1,9) (Table 1).

The vegetation zones as proposed by Ripperton and Hosaka are used as a means of classifying the potential forage productivity of the islands. These vegetation zones were based on the relationship between vegetation, rainfall, altitude and soil.

Precipitation in Hawaii is made up of three components: orographic, cyclonic, and convectional rainfall. Average annual rainfall varies from less than 10 inches to over 300 inches. Due to the variable nature of the Hawaiian Islands, the arable dry soil, the steep wet soil and the arable soil with sufficient rainfall occur as small units, often over short distances.

Using the general classification of vegetation, four formations can be determined on the Hawaiian Islands: shrub, forest, parkland, bog and moss-lichens. These formations tend to arrange themselves into regular pattern on the mountain slopes as one progresses from the very dry leeward side of the island to the wet windward side. The vegetation changes from almost tropical conditions at sea level to a temperate climate in the highlands.

Zone A - Found on the leeward side of the islands or on low windward lands having no mountain background high enough to cause precipitation, and extends from sea level to less than 1,000 feet. Warm, dry summers and cool winters are normal. Annual precipitation is less than 20 inches and normally occurs in December-March as storms move through the area from the south. The vegetation consist of lowland shrubs with scattered trees and mainly annual grasses (buffel-grass is well adapted to this area).

Zone B - Above zone A, if present, normally occurs as narrow coastal strips on the windward side. Zone B can extend to over 3,000 feet in elevation. Rainfall varies from 20-40 inches. The climate is similar to zone A with effective rainfall determining actual use. Both annual and perennial grasses are present and ground cover is good; composed mainly of low shrub. Guinea grass

(Panicum maximan L.) and koa haole (Leucanena leucocyshala, Lam. de Wit) are the most productive forages. However, buffel, bermudagrass, glycine, stylo, and green panicgrass (P. maximan var. trichoglune Eyles) are also productive here.

Zone C - Lies above zone B except where it reaches the sea. This zone extends from sea level to less than 4,000 feet elevation and is divided into two phases: a low phase (C₁) below 2,500 feet elevation and a high phase (C₂) from 2,500 to 4,000 feet. The best farmland in Hawaii is normally found in C₁ with excellent pasture land available in C₂. The annual rainfall is 40-60 inches mainly influenced by tradewinds. Therefore, many summers are distinctly dry.

The vegetation provide an excellent ground cover of perennial grass and forbs. Guava (Psidium guajava L.) is the predominant shrub below 2,000 feet. Phase C₂ was originally forested, but now consists of mixed stands of trees such as Eucalyptus and Acacia and grasslands. The grasses range from tropical to temperate. Kikuyugrass (Pennisetum clandestinum) and Pangolagrass (Digitaria decumbens) are the dominant grasses. Fescue, perennial ryegrass (Lolium perenne), orchardgrass (Dactylis glomerata), Setaria (Setaria sphacelata), rescue grass (Bromus unioloides) and rat tail (Sporobolus africanus), are prevalent above 1200 feet. Legumes also vary from tropical Desmodium species to temperate region clovers (Trifolium spp.), rabbit foot clover (T. aruensi), and big trefoil (Lotus uliginosus).

Zone D - Occurs on the windward crests of the lower mountains and the higher levels on the leeward sides. This zone is divided into three ^{phases} and extends from sea level to 7,000 feet. In the low phase (D₁) ranching is usually restricted to poorer soils. In the middle phase (D₂) most of the land is forest reserve and acts as the principal source of artesian, tunnel, and surface water for agricultural and urban use. Maximum rainfall is over 300 inches. The high phase (D₃) is above the area of maximum rainfall and varies from 1,500-5,000 feet elevation. Zone D₃ contains some of Hawaii's most important temperate zone pasture land. The climate is mainly of tradewind origin (except for the Kona district on the Island of Hawaii).

Guava is again the most characteristic forb. Ohia (Meterosideros collins) and acacia koa form dense forests and slaghorn fern (Dicranopteris linearis and Boston fern (Nephrolepis exaltata) are common in the cleared areas. The dominant grasses are carpet grass (Axonopus compressus) and Hilo grass (Paspalum conjugatum). The improved forage grasses in this area vary from kikuyugrass and pangolagrass in the low phase to temperate zone grasses and legumes in the high phase, including orchardgrass, ryegrass, fescue clovers, and big trefoil.

Zone E - Occurs at higher elevation only on the islands of Maui and Hawaii. It lies above the high phase of D₃ in wetter localities and above the high phase of C in drier areas. The low phase (E₁) consists of plateau parkland ranging from 1,500-5,000 feet elevation; the middle phase (E₂) is dominated by dwarfed trees and some grasses and forbs and varies from 5,000-7,000 feet elevation. The high phase (E₃) occurs above 7,000 feet and the principle

vegetation are moss and lichens. Rainfall is less than 50 inches. Average annual temperature is low 39-59° F and frosts are common. Pasture plants consist mainly of cold tolerant species.

The ranchers utilize the elevation and local rainfall patterns as part of the management by moving animals from one area to the other depending on forage production.

The production of forage as influenced by season of the year and fertilizer applications are presented in figures 1 and 2. There is a distinct reduction in forage production during the winter and early spring months. A similar trend is found for low elevation areas; however, the forage production continues at somewhat higher levels than at higher elevations (3).

There is also a marked seasonal variation in protein and mineral content of Hawaiian forages. The protein content appears to be inversely related to both temperature and day length. Phosphorus and calcium content of grasses follow the trend of protein, being low during the summer periods. Tropical legumes such as koa haole, Desmodium, glycine, etc., follow temperate zone legumes with higher crude protein and mineral content than grasses.

The average ranch in the rougher portion of Hawaii has very large paddocks--1,000-5,000 acres. This factor leads to over- and under-utilization in the same paddock. In general, the livestock producer has not been willing to spend the \$1500 to \$2000 per mile of fence necessary to subdivide the paddocks. The rough terrain does not lend itself to easy fence building. Fencing costs are further complicated by short useful life. A useful life of 8-12 years for most fence is not uncommon in Hawaii. Recent trends in pasture management are moving toward smaller paddocks and rotational grazing management systems. One of the major reasons for this recent shift in pasture management is the increasing use of commercial fertilizers. The record keeping necessary for economical analyses of the returns from fertilization has helped the rancher manage his forages for higher production.

The effect of moving cattle into or off a paddock according to forage production was observed in recent fertilizer trials with Kahua Ranch. One kikuyugrass paddock with a long-time average carrying capacity of 4-5 acres per animal unit under a regime of 6 months' grazing was followed by 6 months' rest. When grazing was adjusted to forage production and forage quality (approximately 5 weeks' grazing and 5 weeks' rest) the same paddock supported cattle at 1.1 acres per animal unit.

Clipping studies indicate forage type to be the major factor in determining frequency of grazing. With grass-legume mixtures involving Desmodium intortum, a rest period of 10 weeks resulted in significantly better legume persistence than a 5-week rest period. Higher yields from kikuyugrass, D. intortum mixtures were obtained with a 10-week rather than a 5-week cutting material (14.4 vs. 6.4 tons/ha ⁽⁵⁾). A similar response to clipping was observed for pangolagrass (14.2 vs. 6.7 tons/ha).

Soil fertility is a major consideration affecting pasture production, especially

in areas where rainfall is adequate. Nitrogen and phosphorus are limiting on large areas of the Hawaiian rangelands. Deficiencies of trace element may be observed in both humid and drier areas. The beneficial effects of pasture fertilization have been well-documented in Hawaii. Young and Ripperton (1960) reported increase in forage production by kikuyu from nitrogen at rates up to 300 lbs./A. Other studies by Whitney and Green (1969) indicate dry matter yields increased from 3780 kg/ha. (control) to 18,000 kg/ha. when 680 kg/ha. of nitrogen were applied.

The cool season growth of kikuyugrass may be increased substantially (3-8 fold) by treatment of the forage with gibberellic acid at the rate of 60 g gibberellic acid per acre.

The adaptability of forages to the prevailing conditions in a given region must be considered. In general, the highest yielding species for the site have been used. Some of the forages grown in the humid South do better than in Hawaii. Bermudagrass is an excellent lawngrass in Hawaii, but it is not very productive as a forage. The daytime temperature appears to be the reason since average daytime summer temperatures are below 84°F. Nighttime temperatures are usually 9° F lower.

The high forage yields possible in the humid tropics are only possible when soil fertility is also high. Therefore, high fertilization rates are required for maximum forage production.

The increase in rainfall and decrease in temperature with increasing elevation are the more important factors influencing forage species in Hawaii. There is about a 3° F decrease in mean temperature for each 1,000 feet change in elevation.

The humid tropics with year-round warm weather, high rainfall and deep porous soils have tremendous potential for forage and cattle production. Management of the pasture is the key to production. Intensive management practices include planting of high yielding nutritious grasses, heavy fertilization, liming, weed control. intensive systems of forage utilization, and year-round planning for a uniform supply of high quality forage to be available throughout the year.

Land areas under United States jurisdiction which may be classified as either tropical or subtropical include the State of Hawaii, the Commonwealth of Puerto Rico, the U.S. Virgin Islands, the Trust Territory of the Pacific, Guam, American Samoa, Southern Florida and the coastal areas of the Gulf of Mexico. These areas present a wide diversity of climates and forages.

Table 1. Vegetation zones

Zone	Annual rainfall, in.	Elevation, ft.
A	< 20	< 1000
B	20-40	< 3000
C ₁	40-60	< 2500
C ₂	40-60	2500-4000
D ₁	> 60	< 1500
D ₂	> 60	1500-5000
D ₃	> 60	4000-7000
E	< 50	> 7000

Table 2. Generalized Effects of Increasing Temperature on Pasture Characteristics

Elevation	Approx. mean annual temp.	Growth and fertilizer response	Improved species	Legumes
feet			Grasses	
> 7000	°F < 51	Slow all year	Yorkshire Fog (Holcus) Ryegrass Orchard grass Tall fescue Rescue grass (Bromus)	White clover Red clover Birdsfoot trefoil Annual medics Rabbit foot clover (T. arvense)
6-7000		Seasonal for temperate species		
5-6000	58			
4-5000		Seasonal for subtropical spp.	Kikuyu Setaria sphacelata	Desmodium spp.
3-4000			Pangola Guinea Dallis Buffel Napier	Glycine wightii Stylo, Leucaena
2-3000	67	Seasonal for tropical spp.		
1-2000				
0-1000	73	Minimal seasonality		

Table 3. Generalized Effects of Increasing Rainfall on Pasture Characteristics

Mean annual rainfall	Soils**	Fertilizer responses**	Improved species	Temperature
< 20 [Very seasonal and erratic]	[Youthful to mod. weathered]	[N, S, Cu Zn on subsoil Some P]	[Guinea, Leucaena Buffel, Bermuda Glycine wightii Kikuyu, stylo]	[White clover Red clover Rabbit-foot clover Annual medics Birdsfoot trefoil Orchard grass Tall fescue Ryegrass]
20-30				
30-40		[N & P]		
40-50				
50-60		[Ca, K]	[Setaria sphacelata Dallis, Pangola Des. spp.]	
60-80		[Mg, Mo]		
80-100		Increasing requirement		[Big trefoil]
> 100 [Relatively dependable]	[Very highly weathered]			

** Will vary according to age and type of parent material.

Table 4. Effects of gibberelic acid on yield and sward characteristics of Kikuyugrass.

Treatment	D.W.	% CP	C.P.	cm ² /g	LSAI	Ht. (7 days before cut)
	lb./A	%	lb./A			in.
<u>Haleakala</u>						
N ₂₀ control	250	12.0*	30	129	0.35	2.7
+ GA	980*	11.1	109*	132 n.s.	1.44*	6.5*
N ₅₀ control	320	14.1*	45	154*	0.55	3.7
+ GA	1460*	12.4	180*	123	2.00*	6.8*
N ₁₅₀ control	1260	15.8*	257	159*	2.25	7.0
+ GA	3290*	14.0	446*	125	4.59*	14.3*
<u>Kula</u>						
N ₂₀ control	30	13.6 n.s.	4	no	no	2.4
+ GA	250*	13.1	32*	data	data	5.3*
N ₅₀ control	80	16.3*	13	142 n.s.	0.16	3.1
+ GA	550*	13.6	75*	132	0.81*	6.7*
N ₁₅₀ control	670	19.2*	128	165*	1.22	5.4
+ GA	2000*	16.5	329*	154	3.43*	10.0*

* Greater than adjacent datum at more than a 95% level of probability.

Table 5. Response of pangolagrass to nitrogen fertilization -- 2-year weight average based on 9 harvests. (Zone - Maui, Hawaii)

N applied annually lbs./acre	Annual D.M. yield lbs./acre	Crude protein %
0	3372	6.8
143	7600	7.3
285	11471	8.7
428	14620	10.6
571	16056	12.6

Table 6. Response of pangolagrass to nitrogen fertilization (zone - Hilo, Hawaii).

N applied annually lbs./acre	Annual D.M. yield ^{1/} lbs./acre	Crude protein %
0	6612	8.8
100	9301	8.4
200	12638	9.1
300	13304	10.7

^{1/} Forage harvested at 6-week intervals.

1. Campbell, C. M., L. B. Sherrod and S. M. Ishizaki. 1969. Effect of supplemental protein and energy levels on the utilization of kikuyugrass. J. Animal Sci. 29:634.
2. Campbell, C. M., C. W. Garcia, J. C. Nolan, Jr., Y. N. Tamimi and E. B. Ho-a. 1971. Beef production from fertilized kikuyu grass pastures in Hawaii. Proc. Western Sec. Am. Society of Animal Sci. 22:95.
3. Campbell, C. M. and E. B. Ho-a. 1971. Effect of level of nitrogen fertilization upon the nutritive value of kikuyu and pangolagrass. Proc. Western Sect. Am. Soc. Animal Sci. 22:101.
4. Ishizaki, S. M. and R. W. Stanley. 1967. The effect of regrowth period on yield, chemical composition and nutritive value of panicum grass. Hawaii Agric. Expt. Sta. Tech. Prog. Rpt. 154.
5. Kamstra, L. D., R. W. Stanley and S. M. Ishizaki. 1966. Seasonal and growth period changes of some nutritive components of kikuyugrass. J. Range Management 19:288.
6. Motooka, P. S., D. F. Saiki, D. L. Plucknett, O. R. Young and D. E. Daehler. 1967. Aerial herbicidal control of Hawaii jungle vegetation. Hawaii Agr. Exp. Sta. Bul. 140.
7. Nicholls, D. F. and D. L. Plucknett. 1971. "Pocket" planting technique for tropical pastures. Hawaii Farm Sci. 20.
8. Plucknett, D. L. 1970. Productivity of tropical pastures in Hawaii. Proc. XI, Inter. Grassland Cong. Australia p. A38.
9. Ripperton, J. C. and E. Y. Hosaka. 1942. Vegetation zones of Hawaii. Hawaii Agric. Expt. Sta. Bul. 89.
10. Sherrod, L. B. and S. M. Ishizaki. 1966. Effects of stage and season of regrowth upon the nutritive value of kikuyu and pangolagrass. Proc. Western Sect. Am. Soc. Animal Sci. 17:379.

11. Sherrod, L. B. and S. M. Ishizaki. 1967. Effects of stage of regrowth and location upon the nutritive value of kikuyu and pangolagrass. Proc. Western Sect. Am. Soc. Animal Sci. 18:279.
12. Tamimi, Y. N., L. B. Sherrod, S. M. Ishizaki and T. Izuno. 1968. The effects of levels of nitrogen, phosphorus and potassium fertilization upon beef production on kikuyugrass. Hawaii Agr. Exp. Sta. Tech. Bul. 76.
13. Whitney, A. S. and R. E. Green. 1969. Pangolagrass performance under different levels of nitrogen fertilization in Hawaii. Agronomy Journal 61:577.
14. Whitney, A. S. and R. E. Green. 1969. Legume contributions to yield and composition of Desmodium spp.--pangolagrass mixtures. Agronomy Journal 61:741.
15. Whitney, A. S. 1971. Effects of harvesting interval, height of cut, and nitrogen fertilization on the performance of Desmodium intortum mixtures in Hawaii. Proc. XI, Inter. Grassland Congr. Australia 632.
16. Whitney, A. S., Y. Kanehiro and G. D. Sherman. 1967. Nitrogen relationships of three tropical forage legumes in pure stands and in grass mixtures. Agron. J. 59:47.
17. Work, S. H. 1946. Digestible nutrient content of some Hawaiian feeds and forages. Hawaii Agr. Exp. Sta. Tech. Bul. 4.
18. Younge, O. R. and K. K. Otagaki. 1958. The variation in protein and mineral composition of Hawaii range grasses and its potential effects on cattle nutrition. Hawaii Agric. Expt. Sta. Bul. 119.
19. Younge, O. R. and J. C. Ripperton. 1960. Nitrogen fertilization of pasture and forage grasses in Hawaii. Hawaii Agr. Exp. Sta. Bul. 124.

The Volatile Alkaloids of Tall Fescue Seed and Forage
(Festuca arundinacea Schreb.): Isolation, Identification
and Effect on Weight Gains of Rats

¹ J. D. Robbins, ² S. R. Wilkinson and D. Burdick ¹

Poor performance and increased respiration rates together with increased temperature have been reported for cattle grazing tall fescue (Jacobson et al., 1970). Abdominal fat necrosis has been found in cattle grazing tall fescue pastures fertilized with poultry house litter high in nitrogen (Williams et al., 1969; Forney et al., 1969). Similar physiological responses and fat necrosis have been observed under experimental conditions in cattle grazing Kentucky 31 fescue fertilized with broiler house litter (Wilkinson et al., 1971).

Fescue is known to contain several alkaloids and a comprehensive review of the alkaloids has been made by Tookey and Yates (1972). The structures of two alkaloids in tall fescue have been determined. Perloline, originally isolated from rye grass, has been found to decrease in vitro digestion of cellulose by rumen bacteria (Bush et al., 1970). Festucine was isolated and identified from Ky 31 fescue by Yates and Tookey (1965).

This report will present data on the following: (1) Isolation and identification of structure of three new alkaloids from Ky 31 fescue seed and forage; (2) Isolation of these alkaloids and rat feeding studies; (3) Levels of N-acetyl loline and N-formyl loline in forage; (4) Levels of these alkaloids in the seed of some tall fescue selections; and (5) A proposed reaction for the biological activity for one of these compounds. This paper will present data to provide a postulate on why tall fescue presents problems when grazed in the summer.

Fescue seed have been shown by Merriman et al. (1962) to be unpalatable to beef cattle. Unpublished data obtained from Dr. M. C. Bell, University of Tennessee, indicated this to be true when Ky 31 fescue seed were fed to rats and these seed contained a growth inhibitor (Bell et al., 1957).

Figure 1 shows the alkaloids previously isolated from tall fescue. Structure 1 is perloline and structure 2 is loline also named festucine by Yates and Tookey when isolated from fescue. Since a number of alkaloids were known to be in tall fescue, we decided to further investigate the basic fraction from forage. Gas chromatography of this fraction indicated that unknown alkaloids were present and these alkaloids were also present in Ky 31 fescue feed in higher concentrations.

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Figure 2 presents the isolation procedure for pyrrolizidine alkaloids from Ky 31 fescue seed. This isolation procedure provided sufficient amounts of the pyrrolizidine alkaloids for identification.

After preparative GLC the three individual alkaloids isolated were subjected to infrared spectrometry and NMR for structural identification.

Figure 1 presents the structures of these alkaloids. Structure 3 is N-acetyl loline, structure 4 is N-formyl loline, and structure 5 is demethyl N-acetyl loline. In this presentation, I will not present the tedious details of structural identification. However, I want to give credit to Dr. Jim Sweeney who is an NRC postdoctoral research associate in my laboratory for his assistance in the isolation and identification of these alkaloids. The proof of structure and synthesis will be published later. For the rat feeding studies, we used a shorter procedure shown in figure 3. In both isolation procedures, the use of strong acids (HCl , H_2SO_4) was avoided. The acetyl and formyl group are easily hydrolyzed from these alkaloids resulting in loline. GLC separation of the alkaloids fed to rats indicated that the mixture was 95-97 percent pyrrolizidine alkaloids and consisted of approximately 70 percent N-formyl loline, 20 percent N-acetyl loline, 4-6 percent loline and about 1 percent demethyl N-acetyl loline.

Two experiments were conducted with rats to determine the effect of these alkaloids on feed intake and weight gain. These data are presented in table 1. In both experiments, the rats were fed a synthetic diet and the alkaloids mixed with the diets. In experiment 1, a preliminary experiment, the rats were fed for 44 days. Experiment 2 was a 21-day experiment. These feeding tests indicate that 0.05 percent of these alkaloids in the diet reduce feed consumption and gains. A marked decrease occurred at the 0.1 percent level of alkaloids in the diet. Histopathology was made of tissues of two rats removed from experiment 1 at 21 days. No pathological lesions were found.

Dr. Stanley Wilkinson, as previously mentioned, had observed the general "summer" signs of cattle grazing fescue at the Southern Piedmont Conservation Research Center, Watkinsville, Georgia. We have analyzed the forage of these pastures for the content of N-acetyl loline and N-formyl loline and the data are presented in table 2. The pasture received 24 metric tons of broiler litter per hectare containing 867 kg of nitrogen in 1969 and 22 metric tons containing 775 kg of nitrogen in 1970. The other pasture was fertilized with 135 kg per hectare of nitrogen in 1969 and 230 kg per hectare of nitrogen in 1970. Ammonium nitrate was used to supply the nitrogen on this pasture. GLC was used to measure the pyrrolizidine alkaloid content of the forage. These data show that pyrrolizidine alkaloids markedly increased during the summer and fall months. In 1970, these alkaloids were more than twice as high on the poultry litter pasture. This pasture produced marked signs of the summer syndrome seen in cattle grazing fescue. These signs are a rough hair coat, loss of weight, rapid breathing, increased body temperature, and a general unthrifty condition. Both pastures at periods had levels above the 0.05 percent level of these alkaloids which showed an effect in rats.

Gentry et al. (1969) reported that perloine accumulated in tall fescue in response to hot, dry weather and nitrogen fertilization. Dr. Wilkinson measured the perloine content on the samples of forage that were analyzed for the pyrrolizidine alkaloids. These data are presented in table 2. The perloine and pyrrolizidine alkaloids levels vary together during the summer months. When these levels are added together, the cattle would be getting more than 0.3 percent alkaloid in their diet during periods in the summer and fall. This raises the question: Can these alkaloids be reduced by selection and breeding? We have analyzed such supplied by Dr. Robert Buckner, ARS, at the University of Kentucky, and part of these data are shown in table 3. These data indicate great variability in tall fescue for pyrrolizidine alkaloids. Therefore, it should be possible to select for low alkaloid content in this forage.

We have postulated on the basis of chemical structure a biological activity for N-formyl loline. It can be suggested that N-formyl loline bears a resemblance to N_{10} formyl tetrahydrofolic acid and may block the enzyme site where N_{10} formyl tetrahydrofolic acid functions as a co-factor in biological methylation reactions. These structural relationships are shown in figure 4.

In summary, the following conclusions can be drawn from our experiments: (1) the pyrrolizidine alkaloids are biologically active. These alkaloids previously have been shown by us to increase the action of acetyl choline. The present data with rats indicates that levels of 0.1 percent in the diet markedly reduced weight gains and feed intake; (2) these alkaloids increase during the summer months, especially under hot, dry weather conditions and high levels of nitrogen; (3) selection can be made in tall fescue for reducing these alkaloids. Such forage should be available to evaluate the occurrence of the summer syndrome observed in cattle and the alkaloid content of the forage.

LITERATURE CITED

- Bell, M.C., Ma, C. S., Merriman, G. M., Underwood, J. K. J. Animal Sci. 16, 1083 (1957).
- Bush, L. P., Streeter, C., Buckner, R. C., Crop Sci. 10, 108 (1970).
- Forney, M. M., Williams, D. J., Papp, E. M., Tyler, D. E., J. Amer. Vet. Med. Assoc. 155, 1603 (1969).
- Gentry, C. E., Chapman, R. A., Henson, L., Buckner, R. C., Agron. J. 61, 313 (1969).
- Jacobson, D. R., Carr, S. B., Hatton, R. H., Buckner, R. C., Graden, A. P., Dowden, D. R., Miller, W. M., J. Dairy Sci. 53, 575 (1970).
- Merriman, G. M., Dyer, I. A., Hobbs, C. S., Bell, M. C., J. Animal Sci. 21, 232 (1962).
- Tookey, H. L., Yates, S. G., Anales De Quimica (In press) 1972.
- Wilkinson, W. R., Studemann, J. A. Williams, D. J., Jones, J. B., Dawson, R. N., Jackson, W. A., Proceedings, International Symposium Livestock Wastes, Amer. Soc. of Agri. Eng., Pub. RR0C-271, St. Joseph, Mich(1971).
- Williams, D. S., Tyler, D. E., Papp, E. J. Amer. Vet. Med. Assoc., 154, 1017 (1969).
- Yates, S. G., Tookey, H. L., Aust. J. of Chem. 18, 53 (1965).

- Bell, M. C., Ma, C. S., Merriman, G. M., Underwood, J. K.
J. Animal Sci. 16, 1083 (1957).
- Bush, L. P., Streeter, C., Buckner, R. C., Crop Sci. 10, 108
(1970).
- Forney, M. M., Williams, D. J., Papp, E. M., Tyler, D. E.,
J. Amer. Vet. Med. Assoc. 155, 1603 (1969).
- Gentry, C. E., Chapman, R. A., Henson, L., Buckner, R. C.,
Agron. J. 61, 313 (1969).
- Jacobson, D. R., Carr, S. B., Hatton, R. H., Buckner, R. C.,
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53, 575 (1970).
- Merriman, G. M., Dyer, I. A., Hobbs, C. S., Bell, M. C.,
J. Animal Sci. 21, 232 (1962).
- Tookey, H. L., Yates, S. G., Anales De Quimica (In press) 1972.
- Wilkinson, W. R., Stuedemann, J. A., Williams, D. J., Jones, J. B.,
Dawson, R. N., Jackson, W. A., Proceedings, International
Symposium Livestock Wastes, Amer. Soc. of Agri. Eng., Pub.
RROC-271, St. Joseph, Michigan (1971).
- Williams, D. S., Tyler, D. E., Papp, E., J. Amer. Vet. Med. Assoc.,
154, 1017 (1969).
- Yates, S. G., Tookey, H. L., Aust. J. of Chem. 18, 53 (1965).

Figure 1

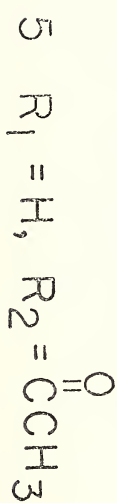
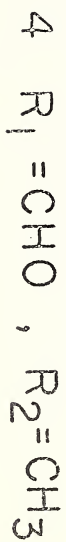
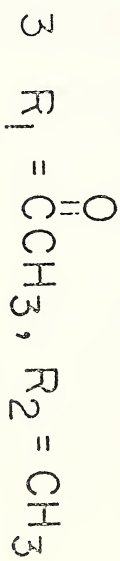
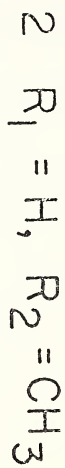
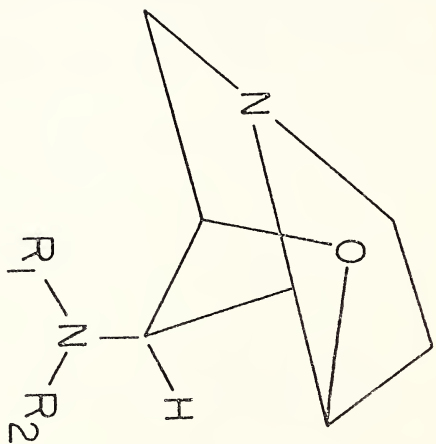
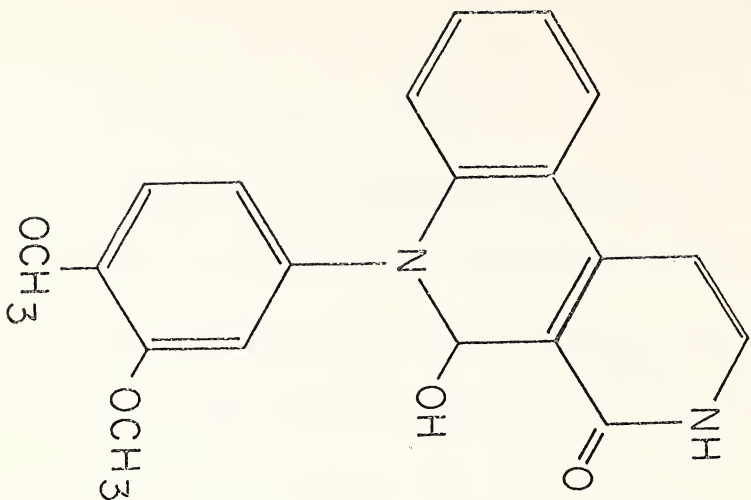


Figure 2

Isolation Scheme of Pyrrolizidine
Alkaloids (Structural Identification)

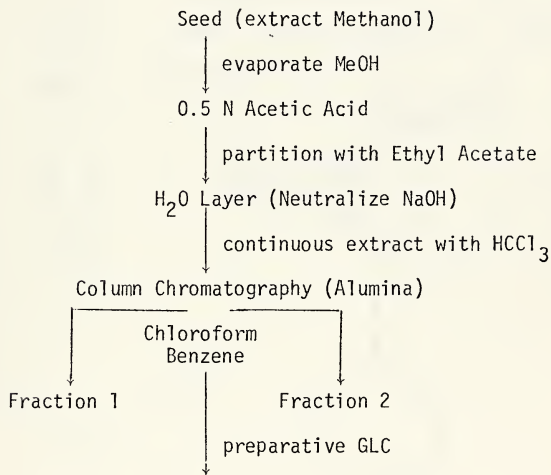


Figure 3

Isolation Scheme of Pyrrolizidine Alkaloids
for Rat Feeding Studies

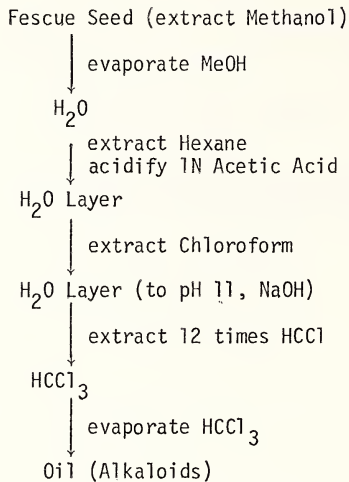


Figure 4

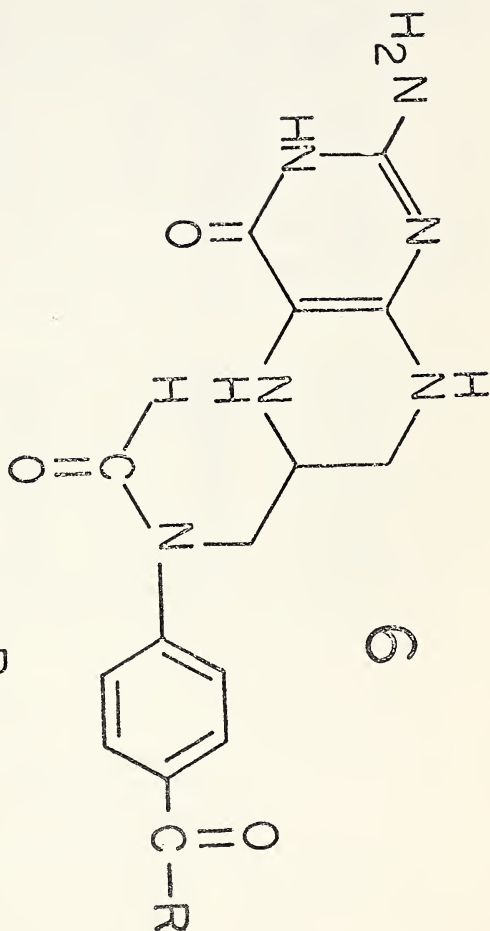
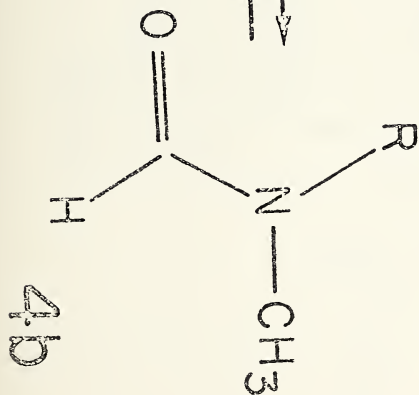
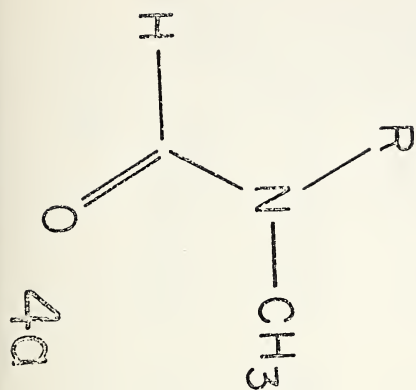


Table 1

Pyrrolizidine Alkaloids of Fescue Seed Fed to Rats

Experiment	Treatment Group	No. of Rats	Percent Alkaloids	Total Feed Consumption (gm)	Total Weight Gain (gm)
1 ^a	1	4	0.0	763	293
	2	3	0.2	493	171
2 ^b	1	10	0.0	302	113
	2	10	0.05	278	93
	3	10	0.1	235	69
	4	10	0.2	161	21

^a4-day experiment^b21-day experiment

Table 2

Levels of Alkaloids in Fescue Forage

Year	Date	N-acetyl loline + N-formyl loline		Perloline ¹	
		NH ₄ NO ₃	Broiler litter	NH ₄ NO ₃	Broiler litter
1969	3/20	.02	.01	trace ²	trace
	4/3	.02	.02	.02	trace
	5/12	.01	.10	.04	.03
	6/12	trace	.03	.02	.04
	7/22	.01	.04	.03	.06
	8/19	.06	.14	.05	.08
	9/15	trace	.01	.04	.04
	10/13	.03	.04	-	.3
	11/10	.02	.02	.01	.01
1970	1/13	trace	.01	trace	trace
	2/17	trace	.02	trace	trace
	3/16	.01	.03	trace	trace
	4/16	.01	.02	.02	.01
	5/18	.03	.06	.08	.04
	6/25	.01	.03	.03	.07
	7/27	.06	.18	.10	.16
	8/10	.05	.16	.10	.16
	9/10	.01	.08	.08	.08
	10/22	.03	.19	.06	.10

¹Wilkinson, S. R. 1970.²Trace amount is less than 0.05%.³Not determined.

Table 3

Levels of N-acetyl Loline and
N-formyl Loline in Fescue Seed

Variety	Percent Alkaloids
Ky 31	0.22
Kenwell	0.29
Goar	0.00
Ky hybrid 1	0.00
Ky hybrid 2	0.01
Ky hybrid 3	0.17
Ky hybrid 4	0.36
Ky hybrid 5	0.49

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SOUTHERN FORAGE EXTENSION WORK GROUP
J. R. Johnson, Presiding, May 16, 1972
The Forage Situation in South Carolina

L. R. Allen
Clemson University

South Carolina is a relatively small state compared to some others represented at the Conference, but we have considerable differences within the State in soils, climatic patterns, and other factors that affect forage production. About 275 different soil series are recognized by Soil Scientists in the State and when you add slope and erosion you get a great number of soil types. Our State land resource map gives some indication of the diversity of soil types, and of soil moisture capacities plus rainfall and temperature patterns show that we have many types of areas requiring different crops or different ways of handling any given crop.

We have roughly a 4 to 1 ratio of cropland to pasture. When you adjust for cropland devoted to hay, silage, and soilage crops you still get a greater than 3 to 1 ratio of cash crops to forage. Like much of the Southeast, our climax vegetation is trees, which is reflected in our having around 5 million acres in open land with nearly 14 million in forests.

At the moment, we do not have a highly organized, comprehensive Extension forage program in the State, with appropriate slogans and other promotional efforts, even though we would like to find a way to have one.

What we do have is quite a number of persons working on various aspects of forage work. We attempt to work together and keep each other informed. We join together in attacking specific problems.

Some of the persons involved are Ag. Engineers working on equipment, Entomologists and Pathologists on forage pests, Farm Management specialists on budgets, etc. We have a free Soil Testing service that is one of our best tools in forage production, a forage testing service (for a nominal fee), and most of us are involved to some extent in applied research.

I have mentioned the soil and climatic differences which require that we have more than one forage program. Also, the fact that cash crops occupy a greater acreage than forages. We have an additional problem which holds back real progress in forage programs and that is the attitude toward forages as a crop. We need to give forage management a higher priority, on the farm and in our research and Extension programs.

Crops such as peaches, tobacco, soybeans, cotton, and vegetables have higher priorities than any forage crop or forage system. This is the crux of the matter regarding forage production and management as we see things in South Carolina at this point.

Also, there are several types of cattle enterprises possible in the state. Different enterprises require different forage systems, and, especially with beef cattle, there are a lot of different reasons why people have cattle. This also affects forage programs. All want to feed their cattle, but some care a great deal about costs and others care less.

★★

C. L. Parks
Clemson University

Grass tetany has numerous factors listed as contributors to the cause. Workers in the Netherlands have suggested that we should keep a calcium-phosphorus ratio of 1.5 in the forage and a base ratio of $\frac{\text{Ca}+\text{Mg}}{\text{Ca}+\text{Mg}}$ of less than 2.2 meq per kilogram. This will not be a difficult problem with the summer grasses, but is not so easy to maintain with the cool season grasses. The cool season grasses are very important to the cow-calf operation in South Carolina. We can use the "ideal" composition they outlined for forage - Mg = .22%, Ca = 0.46%, K = 2.46, and P = 0.36%. The species difference in absorption of bases is evident when we compare the composition of a clover and a grass. The large increase in the uptake of calcium by the legume may be part of the reason grass tetany is not found on a legume pasture. When we attempt to maintain this balance in the cool season grasses the soil temperature becomes a major factor. This could be the reason "Grass Tetany" occurs the season of the year when the soil is cold.

In checking a couple of pastures where tetany was a problem, we find that calcium is low and potassium and phosphorus is high, thus we have an undesirable balance if the Netherland data is correct.

Our plans are to add phosphorus and lime to the soil when it is prepared for seeding the pasture, thus permitting the lime and fertilizer to be incorporated with the soil. If this part is carried out successfully and you have a soil pH of 6.5 and a soil testing high in phosphorus, it will only be necessary to add potassium to legume-grass pastures and nitrogen and potassium to grass pastures. With this procedure, obtaining a given nutrient balance in the plant will be difficult but the chances will be considerably greater than when phosphorus and lime are also applied to the surface.

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Closed-Circuit Educational T.V. Programs on Beef Production and Management

J. N. Williams II
Clemson University

In 1972, plans were initiated to present a comprehensive program on beef production and management by closed-circuit educational television to the beef producers of South Carolina. The purpose of such programs was to bring producers the latest research findings and up-to-date information thereby increasing beef cattle knowledge to producers and extension workers.

The interdisciplinary approach was followed in planning and carrying out this endeavor. The Clemson University Livestock Committee was consulted first. This committee is composed of an Agronomist, Farm Management

specialist, Entomologist, Agricultural Engineer, Information specialist, Area Livestock Agent, District Extension Leaders, selected members of the Animal Science staff, and is chaired by the Associate Extension Director. This committee approved of the proposal and the chairman appointed an interdisciplinary subcommittee to formulate and present the programs.

In the first meeting, the subcommittee discussed program content and concepts and asked the Associate Director to contact all county agents for suggestions on program needs in the counties. A large percentage of the county agents responded, and many suggestions were received. In subsequent meetings, the program content was decided upon by the subcommittee and assignments were accepted by staff members. The head of the Agricultural Communications Department coordinated efforts with the South Carolina Educational Television Network to schedule and show the programs. The Director of University Communications was called upon to introduce programs and his staff prepared charts and made movies and slides for the instructors in addition to taping the programs when finalized.

Taping of the programs was complete by mid-November.

Length of Time
(Minutes)

TV Program #1

COW AND CALF OPERATIONS

10	Outlook and Situation
30	Performance testing, Identification
10	Selection of breeding animals

TV Program #2

COW AND CALF OPERATIONS (Continued)

20	Feeding, Creep feeding, minerals
25	Forages for cow herd

TV Program #3

COW AND CALF OPERATIONS (Continued)

30	Crossbreeding
15	Reproductive efficiency
	Pregnancy checking

TV Program #4

COW AND CALF OPERATIONS (Continued)

10	Diseases and parasites
15	Budget for cow-calf operations
15	Facilities and equipment for cow-calf operations

TV Program #5

FINISHING CATTLE

10	Selection and marketing
	FEEDING PROGRAMS
15	Grain on grass
20	Dry lot

FINISHING CATTLE (Continued)

20	Equipment and facilities
15	Budget for finishing cattle
10	Disease and parasite control

TV Program #7

STOCKER OPERATIONS

20	Stocker programs, buying and selling
30	Feeding programs, fescue and annuals, silage, hay

TV Program #8

STOCKER OPERATIONS (Continued)

15	Diseases and parasites
10	Equipment
15	Budget for stocker operations

Note that each program segment was planned to run from 40 to 50 minutes and that each program had two to three subjects.

Agents were requested to indicate whether or not they would participate in the educational television programs. All 46 counties indicated the desire to participate with meeting locations from one to three per county.

During the Biennial Extension Conference in December, agents who were to be involved with the programs were called into a meeting to discuss procedures for promoting and organizing for the educational effort. A guideline for their use was prepared and presented to them. This included the time for each program to be viewed, suggestions for arranging for television receivers (mostly at vocational agriculture departments and technical education centers), and for conducting the programs. In addition, a brief resume was included in the guideline for their use in introducing the program and also for being prepared to answer questions concerning program content. Eighteen different pieces of material were prepared specifically for the educational television programs. These were listed along with other materials for reference in the guidebooks.

Programs were beamed from the South Carolina Educational Television Network in Columbia beginning at 7:10 p.m. each night of January 3, 6, 10, and 13. Two programs were viewed each of the four nights. All 46 counties participated, and there was an average attendance of 604 persons for each of the four showings. An evaluation was requested of the county agents and farmers. Comments were generally favorable. Representative of these were the following: suggest a series of three instead of four; should have a question and answer session at the end of the program; would like to have access to the same visuals as seen on the screen; and several counties suggested use of open-circuit television for future programs.

**

W. L. Northern
Clemson University

The computer was first used in Dairy Extension at Clemson on dairy cattle nutrition to make calculations on our Forage Testing Program; and since that time, we have added programs so that the computer is used considerably in Dairy Cattle feeding.

In passing, I want to say that we in Dairy Extension feel that Forage Testing is just as important to the dairy farmer as is soil testing to all farmers.

In addition to the Forage Testing program, we use the computer for formulating "least cost" rations, "All in One" rations, and what we have chosen to call "Complete silage" rations.

This is how they work:

Forage Testing - The dairymen secure forms from county agents to sample silage, hay, or grain. He fills out form, and sends both sample and form, to commercial laboratories along with lab fee (\$5.00). The lab analyzes for crude protein, crude fiber, as well as, moisture and PH (silage). The commercial lab sends us this information and we calculate with the use of the computer, digestible protein, total digestible nutrients (TDN), estimated net energy (ENE), on an as fed and dry matter basis. All of this information is then returned to the dairymen with copy to the county agent.

"Least Cost" Ration - In this program, the dairyman secures form from county agent. He requests a ration of a specific crude protein, crude fiber, ENE, calcium, and phosphorus content. The dairyman reports the cost of the feeds that are available to him both home grown and commercially. With the use of the computer we calculate the least cost ration to meet his specifications for a cost of \$1.50

"All In One" Ration - This program is similar to the "least cost" ration in what the dairyman reports. We ask the computer to calculate a ration of 12-14% crude protein, 18-20% crude fiber, a minimum of 60 therms/100 lb ENE, .7% calcium, .5% phosphorus, 1% trace mineral salt, 1,500,000 vitamin A and 1,500,000 vitamin D. The cost of this program is \$1.50

"Complete Silage" Ration - In this program, the dairyman must have his silage analyzed and must request this computation on forms available from his agent. Again the price of feeds available on the farm and locally are reported. We ask the computer to work a ration on a dry matter basis to contain about 40% concentrate and 60% silage, as well as, 12-14% crude protein, 16-20% crude fiber, a minimum of 58 therms/100 lbs. ENE, .7% calcium, .5% phosphorus, and 1% trace mineral salt. The cost of this program to the dairyman in addition to the silage test, is \$2.50

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Selling a Forage Educational Program
N. D. Morgan, Potash Institute

Mr. Johnson - Members of the Extension Forage Work Group - and others who are interested in forage programs -

It is a real pleasure for me to be here to discuss my subject, "Selling a Forage Educational Program".

I want to say at this time that I do not have nearly all the answers, and I know that you can help supply some of them during the discussion period.

I have some suggestions which are really working in my section of the country and I think they will work equally as well in your area.

The first requirement in selling a forage program is that one must wholeheartedly believe in it. One cannot sell it if he does not believe in it. I once heard a Dean of Agriculture say to a couple of people working with forages, "You are not selling a forage program because you do not believe in it strong enough yourselves." I knew the two men well and the Dean told them the truth.

In order to sell a forage program a person has just about got to, so to speak, eat it, drink it, sleep it and talk it so much that some people may think he is a fanatic on the subject. It is much harder to sell a money making pasture program than it is to sell a cotton program, a corn program, or a soybean program because it involves making many more important decisions, such as when to graze, when to rotate, when to make hay in the rotation, etc.

To be a good forage man, one must be dedicated to the subject and not just a "job filler". He must be a salesman of "money making" forage information. Just passing out information that was read in a book or bulletin will not get the job done.

Too many books and too many bulletins don't contain the real money making information which farmers need. The key points involved in profitable forage programs are not included in most publications.

Yes, there is some very good research information, but there are many publications which are of no value except for the authors to add to their list of publications.

This reminds me of a recent letter and enclosure which I received from an Editor of a farm magazine. The enclosure contained the results of a forage experiment. The results showed the unfertilized pasture to be more profitable than the fertilized pastures. The Editor of the magazine wanted my comments.

In checking the experiment, I found that the same stocking rate was used on the fertilized pastures as on the unfertilized pastures.

Apparently the Experiment Station man had not yet learned that forage must be utilized in order to make a profit. Extra cattle were not used to utilize the extra forage produced as a result of fertilization. Therefore, fertilization did not pay according to the conditions of that experiment. I know of many more such publications and they are holding back money making forage programs.

I think that people working with forage programs should have enough experience in the field working with cattle and forages that they can properly evaluate the difference between good research and poor research - and not accept it as a fact just because some researcher conducted an experiment.

Good research is of untold value when used along with field experience in observing forages and cattle.

A few years ago, some of us interested in forages were discussing the subject. Data showed that most of the farmers of the area were using 3 - 5 acres of land or more pre brood cow, or brood cow equivalent.

Considering these stocking rates and the low percentage calf crop, it was easy to determine that most livestock producers were not making any labor-management income. They were selling only 15 - 25 calves per 100 acres of land.

By searching far and wide we found information indicating that a brood cow with calf needed about 6 tons of high quality forage for their yearly nutritional requirement. We, also, found data indicating that we could grow this amount of forage per acre on most of our soils with high fertilization.

With this information we believed that a farmer should be selling 90 calves or more per 100 acres of land instead of his present 15 to 25.

As a result of our discussions we proposed that the Extension Services and Plant Food Societies in the Southwest initiate some possible high profit forage-livestock programs.

It was suggested that these demonstrations consist of 30 brood cows with 30 calves and one bull be placed on 30 acres of land divided into 3 ten-acre pastures. These pastures were to receive top fertilization and top management. We asked the soil test people to make recommendations high enough to make sure that fertility would not be a limiting factor.

It was agreed that such a program had a lot of potential and that a team approach would be used. The first such demonstration was in Texas where the Extension Director suggested the use of a Forage Crops Specialist, a Beef Cattle Specialist and a Farm Management Specialist along with a representative of the Plant Food Society to serve on the team to plan and conduct the demonstration.

The Plant Food Society agreed to pay half the cost of the fertilizer the first two years of the demonstration. The farmer would pay all other costs including liming, fencing, seeding, water, etc. and take care of all fertilizer costs after the first two years.

Extension District Agents selected the counties for the demonstrations. The pasture committee with the assistance of the county agent selected the farmer who would be the demonstrator.

Knowing that each demonstration would require a lot of supervision, only a few demonstrations were set up. They were so successful that it was only a short time until the committee had a long list of requests for more demonstrations.

Similar programs were inaugurated in Arkansas and Louisiana. In some cases, local business organizations, such as banks, news media, radio, TV, fertilizer manufacturers, etc. contributed the needed finances instead of the Plant Food Societies to assist in the demonstrations. The use of local contributions works out exceptionally good because it gets agri-business people involved in the program.

The Extension Service, in all cases, has served as the official agricultural leader.

Our largest demonstration now is 500 cows and 500 calves on 500 acres. We have requests for 2 other large demonstrations to be about 100 acres in size and one for 700 acres. No financial assistance has been requested or given in these large demonstrations. The smaller demonstrations proved so profitable that farmers are now asking for these large demonstrations in order to get the technical assistance.

Most of our cow-calf demonstrations are making a profit of 50-75 dollars per acre. The stocker grazing program, winter grazing of weaned calves, is making about 100 dollars per acre.

Using these demonstrations for Field Days and tours along with the result information therefrom put together by the Farm Management and Agronomists we have a real forage educational program underway in the Southwest.

Our farmers, as well as our agricultural leaders, have learned many things from our demonstrations. We have learned that a top fertilization program is a must if we are going to grow a profitable quantity of high quality forage. We have, also, learned that the forage must be utilized in order to be profitable, and that when we use it, we don't kill it.

Our demonstrations have proved that we can stock our pastures at a cow and calf per acre and in some cases at a higher stocking rate, on most of our soils.

The good nutrition provided by the pasture demonstrations increased percentage calf crops from 70 - 75 percent to above 95 percent.

In conclusion the pasture demonstrations in the Southwest have shown agricultural leaders and farmers that good fertilization of forages plus good management (utilization while young and tender) makes possible a stocking rate of 100 brood cows on 100 acres of land with a percentage increase in calf crop of 20 to 25 percent. Under this program farmers are selling 95 or more calves per 100 acres of land instead of the usual number, 20 to 30 calves per 100 acres.

FERTILIZE AND UTILIZE FOR A TOP-PROFIT FORAGE-LIVESTOCK PROGRAM.

**

Industry Sponsored Pasture Demonstrations

W. E. Monroe
Louisiana State University

In order for you to have a better understanding of our approach to forage demonstrations where industry is cooperating, I feel it is well for you to know at least a small amount of information about our forage and livestock situation in Louisiana. According to the 1969 Agricultural Census Louisiana has 1,252,265 acres of open pasture land and 1,417,000 head of cattle and calves. At a glance this looks as if we have already reached the ultimate goal of having one animal unit per acre, but these figures do not tell the whole story. In addition to the 1,252,265 acres of open land of which only about half is improved, we also have according to the census 673,700 acres of woodland pastures and 1,170,403 acres of irrigated land used for pasture. (Most of this is idle land in a rice rotation). Thus, you can see we have slightly over 3,000,000 acres of land devoted to forage production.

To clarify the picture even more the figure of 1,417,000 head of cattle and calves is misleading, only about 860,000 are potentially productive females. Forget the first glance and come down to reality and it's easy to see we have about 4 acres of pasture land for each productive cow and this does not include 300,000 acres of hay meadows.

We have come a long way in forage improvement programs, but you can see we have a long way to go. On this 4-1/2 acres per cow, we have an 80 percent calf crop and the weaning weight averages slightly above 350 pounds.

Most cattlemen are following a cow-calf operation with the more progressive producers carrying the light calves to heavier weights on winter pasture.

The warm season forage crops consist of bermudagrass both common and coastal, dallisgrass, and bahiagrass. These are grown with and without clover. Alicia bermudagrass is the latest addition to the warm season crops. The cool season annuals are ryegrass, rye and wheat.

You now have a fair picture of the situation and it's easy to see that a profitable cattle industry cannot be developed without improvement in this situation. Even if the forage program is not highly developed at this time, it still offers the greatest opportunity for expansion of agricultural income in Louisiana. Realizing this fact along with the idea that a highly improved forage production and utilization program would benefit all agri-business industries as well as the cattlemen, it was decided to follow the demonstration route to put into effect research findings that had proved profitable.

Our first 30 acre pasture demonstration was sponsored by the Old National Plant Food Institute and was attempted to be patterned by the successful demonstrations in East Texas. Like many things this demonstration was not fully successful. An excellent job was done in forage production, but the utilization left much to be desired. A good cooperator was selected, but

in how much hay could be produced from the pasture than the production of beef. As a result we had grass knee deep much of the time, with the most contented cows you have ever seen to have such poor gains on the calves. Even though this demonstration was not completely successful, it was not a total failure. We at least learned that it's not much trouble to grow a lot of forage, but to utilize it profitably requires skilled management.

In considering a pasture grazing management program it's well to think about what an animal can do with the first tender blades of grass in the spring of the year. Regardless of the type of grass being used, the new growth of spring is more palatable and nutritious than it will ever be again. Any type of spring grass will stimulate milk production causing calves to make rapid gains at least for a while. There is no known way to keep even highly desirable species of grass in this stage of quality all during the year. However, a good grazing management program is keeping it as near as possible to the way it was in the early spring. To do this it is necessary to use enough fertilizer to keep the grass growing and using enough grazing pressure to keep the grass short. A grazing rotation is necessary to accomplish this. With these few lessons in mind, we were ready to attempt another demonstration. By this time the NPFI had discontinued their support of such demonstrations. That left only local sources to finance and sponsor the next demonstration.

In soliciting sponsors some thoughts were given to agri-business industries that would benefit directly from an improved forage program. Anytime farm economy is improved it benefits all segments of the economy, but some industries are more closely associated with forage production and utilization than others. Fertilizer, seed, equipment, banking and herbicidal industries are directly associated with the forage program and will be the first to benefit. These were contacted first, but our second demonstration had a very unusual sponsor. KWKH radio station in Shreveport has a strong agricultural department and have actively sponsored pasture demonstrations.

We feel industry is delighted to sponsor pasture demonstrations as long as they know what is going on and think they are getting their money's worth. This is a form of product development as well as advertising. Industry has been kept well posted of all the activities and results.

Selecting sponsors may be slightly different in all States but keeping them informed on progress is important in every State. Instead of going into details about getting financial support, I would like to mention the methods and results of successful demonstrations.

Our demonstrations consist of three ten-acre pastures being grazed by 30 cows, their calves and one bull. Thirty acres were chosen as this represents a one-bull unit if the pasture is capable of carrying one cow and calf per acre. Three pastures were selected as we felt it would take three acres to be able to use the forage efficiently. However, after 5 years of demonstration work

we feel four pastures would be better than three, except for the extra cost of fencing.

The 30 cows are concentrated on a ten-acre plot and allowed to remain there as long as forage is available. They are then rotated to another pasture.

The third pasture may be beyond the stage of high quality grazing, but it is still in a stage for good hay. If necessary, a cutting of hay is made for winter use. This not only provides high quality hay, but stimulates the growth of grass giving excellent grazing. The length of time the animals remain on one pasture depends on the size of the animals and weather conditions. It's much better to pay close attention to the pastures and move the animals when necessary rather than trying to rotate on a regular schedule.

Warm season sod makes a good seedbed for cool season annuals, if proper grazing management practices were followed all year. The seed must come in direct contact with the soil and a high level of fertility must be maintained if large amounts of high quality forage are expected. The forage grown from the overseeding along with the hay cut from the area is adequate to maintain the herd through the winter.

The second pasture demonstration was much more successful. Four hundred and nine pounds of salable beef per acre was the lowest amount produced in a dry year, but this was at a net profit of \$52.00 per acre.

The sponsors were kept well informed on progress and were invited to all the tours.

Five other demonstrations are now in progress and all are showing remarkable results.

Industry also promotes forage work by sponsoring a pasture tour each year.

Pasture demonstrations sponsored by industry are not limited to white farmers. A winter pasture demonstration was set up on the Latin farm in DeSoto parish. Mr. Latin grazed 20 steers on 11 acres and averages nearly 2 pounds per daily gain.

Demonstrations sponsored by industry are helpful to all segments of agriculture.

Wendell Bowers

Oklahoma State University

All cow-calf operators are looking for an improvement in their forage system which will (1) cut costs, (2) save time and (3) be easier to manage. Traditional systems involving loose hay or baled hay cost too much or require too much labor. Costs to cut the hay and put it into storage will range from one-third to one-half of the value of the crop. Some methods have high labor requirements, often taking two man-hours per ton of 20% moisture hay equivalent to take it from field to storage. The problem doesn't end when the hay gets into storage. In fact, for some operators the labor and inconvenience of feeding forage is their biggest problem. Besides the high cost and labor requirements, cow-calf operators are also concerned with the effect of their system on forage quality and the level of management required.

Within the past few years, several new forage systems have been developed. During the summer of 1971 several of these systems were operating in Oklahoma. This paper will present some data and observations based on field studies of these systems. Each of these systems will be evaluated on (1) labor requirements, (2) cost and (3) value as a management tool. Systems considered in this study include:

- 1) Baled hay with automatic balewagons
- 2) Loose hay with 3 and 6 ton stackwagons
- 3) Loose hay with a tractor buck rake
- 4) Ensilage
- 5) Cubing by field and stationary machines

Comparison of Machine Capacities and Labor Efficiencies

The tables on pages 2 and 3 provide figures for estimating rates of performances for various machine operations in forage systems. Figures are averages based on long periods of use and not short, highly productive periods. Three levels of field efficiency are given. To qualify for use of the high values, an operator must be extremely well organized with no more than five percent of the time in the field lost due to breakdowns, wasted motion, etc. The fields need to be large and designed to eliminate as much deadheading and turning as possible with each machine being used to full capacity at all times. Low field efficiencies must be used if machines and men are non-productive from 15 to 20 percent of the time they are in the field. Be sure to include all of the time that work is stopped due to a breakdown, servicing, rest breaks, deadheading, etc. For example, a 20 minute rest stop twice a

day takes up more than eight percent of an eight hour day or more than eleven percent of a six hour day.

CAPACITIES AND LABOR EFFICIENCIES OF VARIOUS OPERATIONS

All capacities in tons per hour.

Labor efficiencies in man hour per ton.

One ton equals 400 lbs. of water and 1,600 lbs. of dry matter.

<u>Operation</u>	<u>Low Field Efficiency</u>		<u>Average Field Efficiency</u>		<u>High Field Efficiency</u>	
	<u>Tons/Hr.</u>	<u>Man Hrs. Per Ton</u>	<u>Tons/Hr.</u>	<u>Man Hrs. Per Ton</u>	<u>Tons/Hr.</u>	<u>Man Hrs. Per Ton</u>
Mow						
7 ft.	2.48	.40	2.86	.35	3.25	.31
9 ft.	3.19	.31	3.68	.27	4.17	.24
Swath						
10 ft.	3.54	.28	4.09	.24	4.64	.22
12 ft.	4.25	.24	4.91	.20	5.56	.18
14 ft.	4.96	.20	5.73	.17	6.49	.15
Rake						
Single	5.34	.19	6.11	.16	6.87	.15
Tandem	9.92	.10	11.45	.09	12.98	.08
Bale						
Low Capacity	4.17	.24	4.82	.21	5.46	.18
Medium Capacity	5.57	.18	6.43	.16	7.29	.14
High Capacity	6.96	.14	8.04	.12	9.11	.11
Haul, Store Bales						
Truck, 3 men, 65 lb. bales.						
$\frac{1}{4}$ mile haul	2.6	1.15	2.9	1.03	3.3	.90
1 mile haul	2.4	1.25	2.7	1.11	3.1	.97
2 mile haul	2.3	1.30	2.5	1.20	2.9	1.03
4 mile haul	2.0	1.50	2.2	1.36	2.5	1.20
Field Cuber	3.5	.29	4.0	.25	5.0	.20
Automatic Bale Wagon						
119 Bale Capacity 75 lb. bales, (14 x 18 x 36).						
$\frac{1}{4}$ mile haul	10.1	.10	11.5	.09	13.0	.08
1 mile haul	8.9	.11	10.2	.10	11.5	.09
2 mile haul	7.4	.14	8.3	.12	9.5	.11
3 mile haul	6.4	.16	7.3	.14	8.2	.12
4 mile haul	5.6	.18	6.3	.16	7.1	.14

<u>Operation</u>	<u>Low Field Efficiency</u>		<u>Average Field Efficiency</u>		<u>High Field Efficiency</u>	
	<u>Tons/Hr.</u>	<u>Man Hrs. Per Ton</u>	<u>Tons/Hr.</u>	<u>Man Hrs. Per Ton</u>	<u>Tons/Hr.</u>	<u>Man Hrs. Per Ton</u>
Automatic Bale Wagon						
160 Bale Capacity						
75 lb. bales,						
(14 x 18 x 36).						
$\frac{1}{4}$ mile haul	13.6	.07	16.1	.06	18.1	.055
1 mile haul	12.0	.08	13.7	.07	15.4	.065
2 mile haul	10.0	.10	11.4	.09	12.8	.08
3 mile haul	8.6	.12	9.8	.10	11.0	.09
4 mile haul	7.5	.13	8.5	.12	9.6	.10
8 Bale Grapple Fork,						
Tractor Pick-up						
Field stacking						
capacity	9.0	.11	11.0	.09	13.0	.08
Load truck, haul,						
unload on stack						
(2 men).						
$\frac{1}{4}$ mile haul	4.0	.50	5.0	.40	6.0	.33
1 mile haul	3.2	.62	4.0	.50	4.8	.42
Loose Hay Systems						
3 Ton wagon,						
stack	4.5	.22	5.2	.19	6.0	.17
6 Ton wagon,						
stack	7.5	.13	8.7	.11	10.0	.10
Tractor buck						
rake	3.4	.29	4.0	.25	4.6	.22
Move 3 Ton stack						
$\frac{1}{4}$ mile	7.5	.13	10.0	.10	12.5	.08
1 mile	3.7	.26	5.0	.20	6.2	.16
Move 6 Ton stack						
$\frac{1}{4}$ mile	15.0	.07	20.0	.05	25.0	.04
1 mile	7.5	.13	10.0	.10	12.5	.08
Silage						
Chop, haul, store						
(2 men, large chop-						
per & wagons).						
Low moisture						
legume @ 50%	7.5	.27	10.5	.19	12.5	.16
Converted to 20%	4.7	.42	6.6	.30	7.8	.26
Corn or sorghum						
@ 60%	25.0	.08	30.0	.07	35.0	.06
Converted to 20%	12.5	.16	15.0	.13	17.5	.11

The tables on pages 2 and 3 can be very useful in making comparisons of different systems. Suppose you want to compare the labor efficiency of a conventional baling system with one using a 119 bale automatic balewagon, for 500 tons per year and a 1 mile haul. Comparison is made assuming a 14 foot self-propelled swather and average field efficiencies.

Man-Hours Per Ton

	<u>Conventional</u>	<u>Balewagon</u>
Swath	.17	.17
Turn with tandem rakes	.09	.09
Bale (medium capacity)	.16	.16
Haul (one mile)	<u>1.11</u>	<u>.10</u>
	1.53	.52

Total hours of labor per year:	765	260
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Labor is the same through baling, but the conventional hauling results in three times as much labor being used. The high labor requirements of hauling is the reason why most of the larger cow-calf operators rely on custom trucking.



Figure 1. Most of the high cost of forage in the conventional system of handling baled hay can be attributed to the hauling, storing and feeding operations. More than twice as many man-hours are needed to pick up the bales and store them in buildings like the one shown on the right than is required for cutting, raking and baling put together. Furthermore, the time lag in getting the bales into storage with this system increases the possibility of rain damaged hay.

Labor Efficiency

The table on page 6 shows typical labor requirements for the various forage systems compared in this study. While there are many possible variations for each of the systems, total labor requirements are believed to be typical for current cow-calf operations in Oklahoma. These figures can be used to make head-on comparisons of different systems. Suppose you have been storing 400 tons of baled hay using the conventional baling system with custom hauling. The table on page 6 shows a total of 1.56 man-hours per ton or 624 (1.56 x 400) man-hours of labor per year. Of this total, 1.11 x 400 x 444 man-hours are needed for the hauling operation. If you went to the 3 ton loose hay stacking system, you would need .63 x 400 or 252 man-hours of labor per year including one move of each stack to the feeding area.

Further discussion of labor efficiency for the different forage systems will be given in the summary.

The table below shows total man-hours of labor required for various amounts of forage handled to provide an equal basis for comparison. The tonnages listed are for amounts of 20% moisture equivalent forage. For example, low-moisture legume silage usually goes into storage at 50 percent moisture. Therefore, the tonnages for low moisture legume silage should be multiplied by 1.6 to obtain actual tons handled of 100 tons would really be 160 tons of forage as it was chopped and stored. In the case of direct cut corn or sorghum silage the multiplier is 2.0, so 100 tons on the table would be 200 tons as stored.

Total Man Hours of Labor Required

	<u>Tons Per Year</u>					
<u>System</u>	<u>100</u>	<u>200</u>	<u>400</u>	<u>600</u>	<u>800</u>	<u>1,000</u>
Conventional Bales	156	312	624	936	1248	1560
Small Balewagon (119 bales)	51	102	204	306	408	510
Large Balewagon (160 bales)	48	96	192	288	384	480
*3 Ton Stacking Wagon	63	126	252	378	504	630
*6 Ton Stacking Wagon	47	94	188	282	376	470
*Tractor Buck Rake	68	136	272	408	544	680
Direct Cut Silage	13	26	52	78	104	130
Low-Moisture Silage	44	88	176	264	352	440
Field Cubing	74	148	296	444	592	740

*Includes Feeding

LABOR EFFICIENCY

Man-Hours Per Ton of 20% Moisture Forage

Operation	Bales		Loose Hay			Silage		Field	
	Conventional	119 Bale Size Balewagon	160 Bale Size Balewagon	3 Ton Loose Hay Stack Wagon	6 Ton Loose Hay Stack Wagon	Tractor Buck Rake	Direct Cut Corn or Sorghum Silage	Low Moisture Legume Silage	Cuber
Mow	----	----	----	----	----	.27	----	----	---
Swath	.20	.20	.20	.20	.20	----	----	.14	.14
Rake	.09	.09	.09	.09	.09	.16	----	----	.16
Bale	.16	.12	.12	----	----	----	----	----	---
Haul	1.11	.10	.07	----	----	----	----	----	.22
Stack	----	----	----	.19	.11	.25	----	----	---
Move Stack	----	----	----	.15	.07	----	----	----	---
Chop and Haul	----	----	----	----	----	----	.13	.30	---
Cube	----	----	----	----	----	----	----	----	.22
TOTAL	1.56	.51	.48	.63	.47	.68	.13	.44	.74

Cost Comparisons of Forage Systems

The following cost comparisons of forage systems are based on situations typical for Oklahoma. There would naturally be many individual variations from the assumptions used, but the primary objective is to provide cost and labor efficiency comparisons for some of the newer systems. The following assumptions were used.

- 1) All labor @ \$1.60/hr. except baling and running a balewagon where labor is charged at $1\frac{1}{2}$ ¢/bale.
- 2) Yields are assumed at 1 ton/acre.
- 3) Machines are owned to wear-out point, least cost, or 10 years, whichever comes first.
- 4) 65 lb. bales (@ 20%) for hand moving.
- 5) 75 lb. bales (@ 20%) for automatic handling.
- 6) Wire tie bales with wire @ 3¢/bale.
- 7) Least size tractor power for each operation. Tractors are used 600 hrs./year.
- 8) Evaluations for 100, 200, 400, 600, 800 and 1,000 tons/year.
- 9) Double windrows with 22 foot spacing unless assumed otherwise.
- 10) Swathing with 12 foot PTO swather.

Conventional Bale System

There are two common variations for the conventional system of handling bales.

- a) Swath, rake, custom bale and custom haul.
- b) Swath, rake, bale and custom haul.

Average Cost Per Ton

a) Swath, rake, custom bale, custom haul.	<u>Tons Per Year</u>					
	100	200	400	600	800	1,000
12 ft. PTO Swather	4.32	3.11	2.10	1.88	1.79	1.73
Rake (2 rakes)	1.68	.98	.76	.61	.55	.53
Custom bale (16¢/bale)	4.80	4.80	4.80	4.80	4.80	4.80
Custom haul (12¢/bale)	3.60	3.60	3.60	3.60	3.60	3.60
TOTAL	\$14.40	\$12.49	\$11.26	\$10.89	\$10.74	\$10.66

b) Swath, rake, bale, custom haul.	100	200	400	600	800	1,000
12 ft. PTO Swather	4.32	3.11	2.10	1.88	1.79	1.73
Rake (2 rakes)	1.68	.98	.76	.61	.55	.53
Bale (medium)	4.91	3.45	2.73	2.53	2.42	2.36
Custom haul	3.60	3.60	3.60	3.60	3.60	3.60
TOTAL	\$14.51	\$11.14	\$ 9.19	\$ 8.62	\$ 8.36	\$ 8.22

Advantage for owning a
baler.

-\$.11 +\$ 1.35 +\$ 2.07 +\$ 2.27 +\$ 2.38 +\$ 2.44

Baled Hay With Automatic Balewagons

This system essentially replaces custom hauling with a one man system for picking up, hauling and storing bales. However, there are some important restrictions that must accompany the adoption of currently available automatic balewagons. Special sizes of storage structures are required for maximum benefit from the automatic balewagons. Operation of these wagons is not a simple process. Younger men with good coordination and "thinking power" make the best operators. They will look at the job as a challenge and will continually work at ways to get more tons per hour. For best handling by balewagons, the bales should weigh approximately 80 pounds as they come out of the baler, which means a 20% moisture weight of about 75 pounds. If the bales are too light, they cannot be picked up properly. If their size is not uniform, they may be broken or cause the stack to become uneven. One or two bad bales can foul up an entire storage unit. The length should be held between 36 and 38 inches which means the heaviest available two wire bales should be used. It is very difficult for lighter balers to make bales this dense without breaking wires. Also, an attachment must be added to leave the bales on edge in the field. The balewagons will handle different sizes of bales, although the 14 x 18 bale is the most common size used in Oklahoma at the present time. Cost for the self-propelled balewagons will run from \$13,000 to \$16,000.

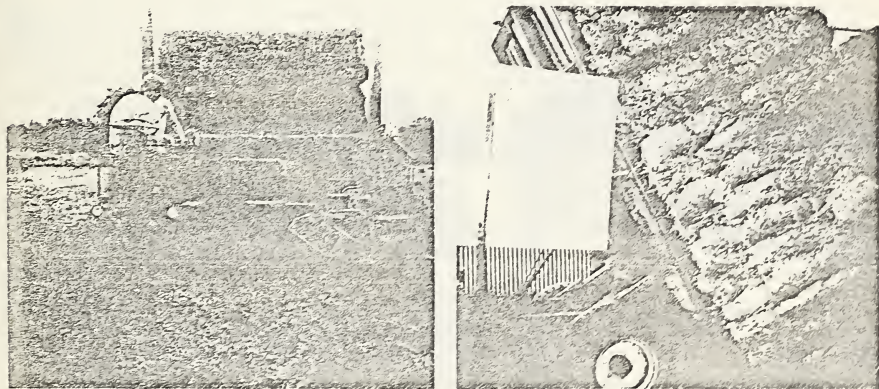


Figure 2. This automatic balewagon can haul and store more than 10 tons an hour. Storage structures must provide at least 16½-17 feet of overhead clearance, have a smooth, level floor with an inside width divisible by 11. (33, 44 or 55 feet)

Cost figures are shown for two sizes of automatic balewagons. Assuming 14 x 18 x 36 bales and 27 bales per ton at 20% moisture, the 119 bale capacity wagon is rated at 10.2 tons per hour for a one mile haul and the 160 bale size is rated at 13.7 tons per hour.

Tons Per Year

	<u>100</u>	<u>200</u>	<u>400</u>	<u>600</u>	<u>800</u>	<u>1,000</u>
Swath	4.32	3.11	2.10	1.88	1.79	1.73
Rake	1.68	.98	.76	.61	.55	.53
Bale	<u>5.37</u>	<u>3.51</u>	<u>2.56</u>	<u>2.25</u>	<u>2.20</u>	<u>2.12</u>
SUBTOTAL	\$11.37	\$ 7.60	\$ 5.42	\$ 4.74	\$ 4.54	\$ 4.38
Haul (119 bale capacity)	14.44	7.94	4.64	3.18	2.73	2.51
Haul (160 bale capacity)	17.15	9.57	5.25	3.84	3.02	2.51
Total Cost/Ton						
119 bale size	\$25.81	\$15.54	\$10.06	\$ 7.92	\$ 7.27	\$ 6.89
160 bale size	\$28.52	\$17.17	\$10.67	\$ 8.58	\$ 7.56	\$ 6.89
Advantage over conventional baling						
119 bale size	-\$11.30	-\$ 4.40	-\$.87	+\$.70	+\$ 1.09	+\$ 1.33
160 bale size	-\$14.01	-\$ 6.03	-\$ 1.48	+\$.04	+\$.80	+\$ 1.33

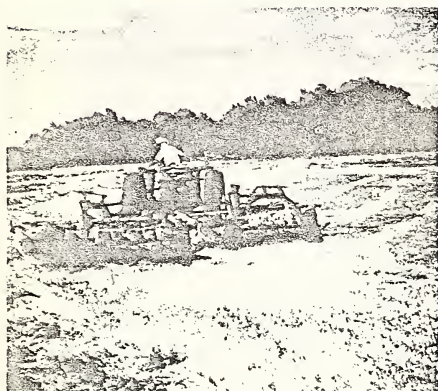


Figure 3. Using tandem rakes to make one large windrow is a good way to save time and money in any sizable hay operation. They are especially desirable in a system using automatic balewagons as they help make uniform windrows and speed up baling. Automatic balewagon systems also require heavy duty balers to make uniform, dense bales without breaking wires and must have an attachment to leave bales on edge in field.

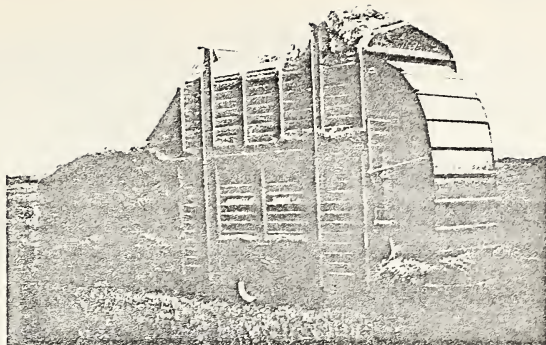


Figure 4. Feeding bales in the winter is a major chore for larger cow-calf operations. To mechanize hay production for operations of this nature, the loose hay stacking wagon has become very popular. The normal process involves stacking the hay a short distance from the field in otherwise useless areas. Then the stacks are moved to feeding areas as needed with a stack mover. Due to the weight of the stacks, tractors typical of the largest row crop sizes are required.

There are several different kinds of stacking wagons on the market. Those included in the 1971 Oklahoma Study are represented in the cost figures below as 3 ton and 6 ton capacity stacking wagons. These models pack the hay several times before the stack is unloaded. The mowing and raking operation would be the same as for the previous operations. Cost will range up to \$13,000 or more for the 6 ton model.

Average Cost Per Ton

Tons Per Year

<u>Operation</u>	<u>100</u>	<u>200</u>	<u>400</u>	<u>600</u>	<u>800</u>	<u>1,000</u>
Swath-Rake	\$ 6.00	\$ 4.09	\$ 2.86	\$ 2.49	\$ 2.34	\$ 2.26
*Stack with 3 ton wagon	8.87	6.79	3.92	3.47	3.24	3.09
*Stack with 6 ton wagon	16.17	8.57	4.78	3.88	3.47	3.16
 Total Costs						
3 ton wagon	14.87	10.88	6.78	5.96	5.58	5.35
6 ton wagon	22.17	12.66	7.64	6.37	5.81	5.42
 Advantages over conventional baling						
3 ton model	-\$.36	+\$.26	+\$ 2.41	+\$ 2.66	+\$ 2.78	+\$ 2.87
6 ton model	-\$ 7.66	-\$ 1.52	+\$ 1.55	+\$ 2.25	+\$ 2.55	+\$ 2.80

*At 1500 tons per year, the 6 ton wagon shows a cost of \$2.81 per ton compared to \$2.87 for the 3 ton model. Total costs would then be \$5.07 per ton for the 6 ton model and \$5.13 per ton for the 3 ton model.

Moving Loose Hay Stacks

With the system for making 3 or 6 ton stacks, three options are available for feeding. (1) The stacks, when made in the field, can be transported directly to the winter feeding areas. (2) They can be moved to an unused area next to the field and moved later to the feeding area. (3) They can be left in the field and moved later to storage area and then moved to feeding areas as needed.

Stackmovers come in different sizes, but the 5 ton unit costing about \$3,500 and operated by a medium-large-size tractor is the most common and will handle either the 3 or 6 ton stacks. The 6 ton stacks usually dry out to 5 tons by the time they are moved. Costs for using the stackmover will vary according to the distance moved, but the following figures provide a guideline for typical situations.

	<u>Average Cost Per Ton</u>					
	<u>Total Tons Moved</u>					
	<u>100</u>	<u>200</u>	<u>400</u>	<u>600</u>	<u>800</u>	<u>1,000</u>
Moving 3 ton stacks	\$ 4.30	\$ 2.91	\$ 1.85	\$ 1.61	\$ 1.51	\$ 1.47
Moving 6 ton stacks	\$ 3.97	\$ 2.28	\$ 1.46	\$ 1.08	\$.93	\$.84

Tractor Buck Rake

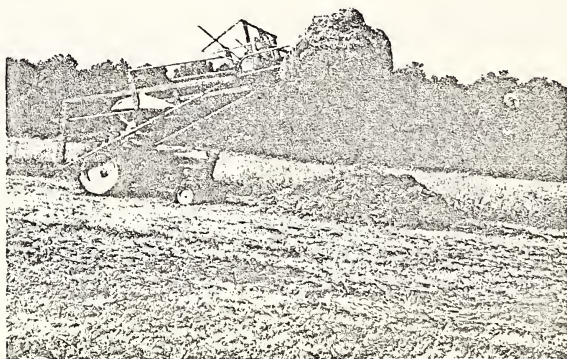


Figure 5. For those cow-calf operators needing 200 tons or less of stored hay for the winter, a tractor buck rake is a good possibility. Besides the mower and rake which nearly every farmer has already, a \$2,000 investment in a tractor mounted buck rake is all that is needed. Hay is stacked in 15-20 ton units.

Tractor Buck RakeAverage Cost Per Ton

	<u>Tons Per Year</u>					
	<u>50</u>	<u>100</u>	<u>200</u>	<u>300</u>	<u>400</u>	<u>500</u>
Mow	2.33	1.88	1.54	1.45	1.39	1.36
Rake	1.94	1.28	.95	.79	.75	.70
Stack with tractor	<u>5.12</u>	<u>3.34</u>	<u>2.32</u>	<u>2.00</u>	<u>1.89</u>	<u>1.81</u>
TOTAL COST FOR BUCK RAKE	\$ 9.39	\$ 6.50	\$ 4.81	\$ 4.24	\$ 4.03	\$ 3.87
If custom baled:						
Custom baling + hauling	8.40	8.40	8.40	8.40	8.40	8.40
Add for mow & rake	<u>4.27</u>	<u>3.16</u>	<u>2.49</u>	<u>2.24</u>	<u>2.14</u>	<u>2.06</u>
TOTAL FOR BALING	\$12.67	\$11.56	\$10.89	\$10.64	\$10.54	\$10.46
Advantage for stacking with tractor	+\$ 3.28	+\$ 5.06	+\$ 6.08	+\$ 6.40	+\$ 6.51	+\$ 6.59

Silage System

Cow-calf operators might use either direct cut corn or sorghum silage or they might use low-moisture legume silage. Costs for these systems will vary considerably and it is hard to present a true picture without including the storage and feeding equipment. The following costs are based on taking the forage from the field to storage in an upright silo with high capacity equipment.

Average Cost Per TonTons Harvested

(at 60% moisture for silage
or 50% moisture for low-moist. legume silage)

	<u>200</u>	<u>400</u>	<u>800</u>	<u>1,200</u>	<u>1,600</u>	<u>2,000</u>	<u>3,000</u>
Direct cut silage (corn or sorghum.)	6.65	3.62	2.17	1.67	1.38	1.25	1.07
Converted to 20% moisture hay equivalent.	13.30	7.35	4.33	3.33	2.76	2.51	2.14
Low-moisture legume silage.	12.14	7.56	5.37	4.72	4.32	4.11	3.82
Converted to 20% moisture hay equivalent.	19.42	12.10	8.59	7.55	6.91	6.58	6.11

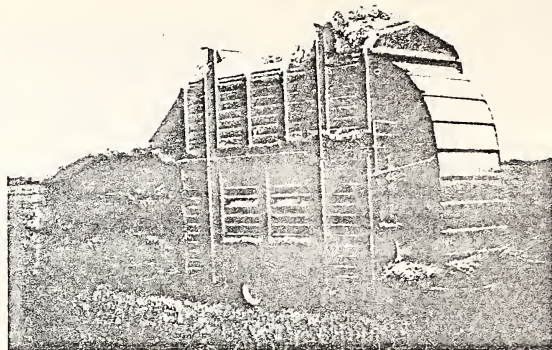


Figure 4. Feeding bales in the winter is a major chore for larger cow-calf operations. To mechanize hay production for operations of this nature, the loose hay stacking wagon has become very popular. The normal process involves stacking the hay a short distance from the field in otherwise useless areas. Then the stacks are moved to feeding areas as needed with a stack mover. Due to the weight of the stacks, tractors typical of the largest row crop sizes are required.

There are several different kinds of stacking wagons on the market. Those included in the 1971 Oklahoma Study are represented in the cost figures below as 3 ton and 6 ton capacity stacking wagons. These models pack the hay several times before the stack is unloaded. The mowing and raking operation would be the same as for the previous operations. Cost will range up to \$13,000 or more for the 6 ton model.

Average Cost Per Ton

<u>Operation</u>	<u>Tons Per Year</u>					
	<u>100</u>	<u>200</u>	<u>400</u>	<u>600</u>	<u>800</u>	<u>1,000</u>
Swath-Rake	\$ 6.00	\$ 4.09	\$ 2.86	\$ 2.49	\$ 2.34	\$ 2.26
*Stack with 3 ton wagon	8.87	6.79	3.92	3.47	3.24	3.09
*Stack with 6 ton wagon	16.17	8.57	4.78	3.88	3.47	3.16
Total Costs						
3 ton wagon	14.87	10.88	6.78	5.96	5.58	5.35
6 ton wagon	22.17	12.66	7.64	6.37	5.81	5.42
Advantages over conventional baling						
3 ton model	-\$.36	+\$.26	+\$ 2.41	+\$ 2.66	+\$ 2.78	+\$ 2.87
6 ton model	-\$ 7.66	-\$ 1.52	+\$ 1.55	+\$ 2.25	+\$ 2.55	+\$ 2.80

*At 1500 tons per year, the 6 ton wagon shows a cost of \$2.81 per ton compared to \$2.87 for the 3 ton model. Total costs would then be \$5.07 per ton for the 6 ton model and \$5.13 per ton for the 3 ton model.

The conventional system of producing and feeding baled hay places severe limitations on cow-calf operations at all levels of production. Small scale operations are faced with high costs and the larger operations have trouble providing adequate labor and management for all of the competing enterprises. In either case, hauling the bales into storage and taking them out again for feeding are the biggest hurdles to overcome. There are several alternatives open to cow-calf operators who want to cut costs, improve the quality of their forage and increase net returns.

The first consideration should be to apply a higher level of management to the present system. There are three different ways machinery costs could be cut by 10% or more. Combined they could mean a 25% reduction for the average operator. (1) Do not over-size equipment. (2) Do not trade too often. (3) Improve maintenance practices. With most hay equipment you can afford to spend one to two days of labor in the off season to prevent a one hour breakdown in the middle of the busy season.

Equipment adjustment is often neglected. Operating too fast with equipment out of adjustment is responsible for excessive field losses. Several individual raking and operations involving a pick-up were observed in 1971 where 20% or more of the crop was left in the field. These were usually operations with unexperienced, minimum cost hired labor.

If you think your operation can provide the high level of management required, an automatic bale wagon system can lead to (1) increased annual production (2) lower production costs and (3) improved quality.

Because the total labor requirements for this system is about one third of a system using hand hauling, savings of more than \$1.00 a ton can be obtained. By using heavy duty balers which are faster and make heavier bales and by using multiple machine units, the system capacity can be increased from 20-100 per cent just to keep up with one large bale wagon. Faster harvest rates means a potential for increasing annual tonnage with a higher level of quality, due to the bales being hauled to storage immediately after they are left in the field. Some operators report handling from 2,500 - 3,500 tons per year with one wagon.

The biggest drawback to the automatic bale wagon system is the level of management and supervision required for all phases of the field operations. The key to the whole operation is dense bales of uniform size. Heavy duty balers are required and should operate at the highest safe moisture level with the lowest pick-up losses, which means running at night in Oklahoma.

If large operations are needing to cut costs and reduce labor where all of the forage is fed on the farm, a loose hay stacking wagon may be the answer. Savings over baling range up to \$3 or \$4 per ton including feeding costs. The loose hay systems would undoubtedly have greater storage and feeding losses, but whether the dollar value of the added losses equals the cost savings has not been completely determined. As long as the operator has the flexibility to always store the amount of hay needed, he may

not be too concerned with the feeding losses. Management of this system is no particular problem. In fact, it may be even easier than for conventional bale systems.

Apparently, quality is the biggest problem with any loose hay system where outside storage is used. Early experiences with some of the loose hay systems in Oklahoma indicate that you cannot stack at a higher moisture than for baling or molding will result. Some care is needed to make good stacks and, in some cases, tie them down to prevent storm damage.

Mechanical moving of loose stacks for feeding is fast, easy and less expensive than handling bales for more than 200 tons a year.

For the operations of 400 tons a year or less, the tractor buck rake system is a convenient, inexpensive way to store roughage for winter feeding. Feeding losses will be high, but costs are so low, it really doesn't matter as long as the stack locations are conveniently located for feeding during the winter.

Silage harvesting costs are always substantially lower and much less labor is required than for hay systems. In the case of silage, storing and feeding must be highly mechanized and are therefore quite expensive. It is for this reason that we do not normally associate silage programs with a cow-calf operation, but further research is needed to see how present day total costs would compare.

Comparison of Field Losses

The table below shows the relationship of field losses to harvest moisture for high quality alfalfa. Losses are expressed as a percent of the nutritive value.

Moisture at Harvest

(percent)

70
60
50
40
30
25
20
15

Nutritive Value of Field Loss

(percent)

4
6
8
14
17
19
23
27

Research by Extension
Report from South Carolina
by
L. R. Allen
Clemson University

Applied research has become an important part of the Extension program with all crops in South Carolina.

Among the reasons for this change from our former way of doing things (research conducted by Experiment Station workers, results reported to Extension, Extension taking the results to the farmers via the demonstrations) are: (1) a feeling that the old approach does not get needed information to the producers fast enough and (2) that applied research on farms would supply information about a wider variety of conditions (soils, weather, etc.) than research performed largely on Experiment Stations.

An administrative change which resulted in joint Extension-Research appointments for many Extension specialists also helped get us into applied research on Extension time.

As noted earlier today, many disciplines at Clemson are involved in inputs to Extension forage programs. I will not attempt to go into how each is involved, but will use my own experiences as an example of where we are.

About two years ago, I was persuaded to accept a joint appointment - 80% Extension, 20% Research. I had a rather limited time to come up with a project proposal. I chose an area involving top-or sod-seeding winter annuals on dormant bermudagrass sod in an area of the state which depends on Coastal bermudagrass as the principal forage for cattle. Early-planted winter rye planted on row crop land provided forage for most of the winter months but left a gap of some 4 to 6 weeks in April and May which had to be filled with hay, silage, or concentrates, all of which are expensive.

It had been suggested for some time that we needed to get some applied research going as a part of the Extension program, but until I was given research responsibilities I had resisted the idea. With a research project to perform, I then saw an opportunity to put out some related applied research plots, so I cancelled our Extension Forage Production and Management Contest and began putting out replicated plots using some of the same plant materials that I was using on my research project. I have since become involved in an alfalfa variety test and have spent some time helping forage research workers find off-station sites for other forage work.

Among the advantages I see about the process after only two brief years is that you become more familiar with the plant materials you are using and the situations in which you use them, and also, that the farmers in the area in which you work seem genuinely appreciative of the fact that you are attacking problems that directly affect their livelihood.

Among the disadvantages in my present set-up is keeping two sets of records, trying to fairly allocate time and resources to research and Extension projects. Also, since forage is not the only area in which I have major responsibilities, I have further scheduling conflicts between forage work and the other areas of work.

Another aggravating situation in my own case is that of having to borrow all kinds of equipment from other research workers or from farmers, as well as getting labor to help me. There is currently not enough money in the program for a regular technician to be supplied me, and not enough funds to adequately provide for all the needed inputs of seed, fertilizer, and equipment. I must add that I have received a lot of assistance from the county agents in the counties in which I am working and from the farmers on whose land the work is being carried out as well as assistance and encouragement from research and Extension workers.

To sum up, the work is rather enjoyable in many respects, but we are not able to do as much as is needed, and because of time and labor considerations, we leave much of the information that could be recorded and analyzed in the field. I feel we have over extended ourselves in many instances and that our role of interpreting research and other information is suffering because of it.

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Research by Extension - What, How, Why, Benefits and Disadvantages

E. Lamar Kimbrough
North Carolina State University

We have a Forage Variety testing program with one Extension Specialist working full time and two assistants helping during the summer seeding and growing period. Forages being tested include: (1) winter and summer annual grasses, (2) perennial cool season grasses and legumes and (3) warm season legumes.

Additional work being done in conjunction with Research and Extension includes: (1) alfalfa variety demonstrations, weed control and insect control, (2) Coastal bermudagrass weed control and overseeding with winter annuals and (3) silage comparisons of pearl millets, sorghum sudangrass hybrids, grain sorghums and silage type sorghums. Replicated treatments are used and data is collected by both Research and Extension people.

Benefits include (1) the location of sites of where the problem exists, (2) affording an opportunity for Extension, Research, Commercial, and Farmer to work close together. Disadvantages include the shortage of time and facilities to allot to specific needs.

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Research by Extension - A Forum Conducted in the Extension Subgroup
of the Southern Pasture and Forage Crop Improvement Conference

S. H. Dobson
North Carolina State University

A survey of Extension forage specialists in the Southern States was made regarding research by Extension specialists. Fifteen workers from 11 Southern States replied. Four States indicated that they were doing "applied research" in replicated plots: Florida, South Carolina, North Carolina, and Virginia. Only South Carolina has a joint appointment, but North Carolina, Virginia, and Florida have joint projects.

Those doing applied research reported on this work and were of the opinion that considerable benefits accrued to the forage program, although funding is presently inadequate. Those States not doing extension type research felt that these additional efforts would further dilute their time and reduce their total effectiveness.

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REGISTRATION LIST - 1972

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Evans, Emerson M.	"	"
Spooner, A. E.	Arkansas	Fayetteville
✓Boyd, Frederick T.	Florida	Gainesville
✓Dean, Charles E.	"	"
Hodges, Elver Myron	"	Ona
✓Johnson, James Troy	"	Gainesville
✓Jones, David W.	"	"
✓Killinger, Gordon B.	"	"
Mislevy, Paul	"	Ona
Moore, John Edward	"	Gainesville
Smith, Rex L.	"	"
✓Wing, James M.	"	"
✓Akin, Danny E.	Georgia	Athens
✓Amos, Henry E.	"	"
✓Barton, Franklin E. II	"	"
Brown, R. Harold	"	"
Burdick, Donald	"	"
Burton, Glenn Willard	"	Tifton
✓Chapman, Glenn W.	"	Athens
✓Cummins, David G.	"	Experiment
✓Dobson, J. W.	"	Blairsville
✓Forbes, Ian, Jr.	"	Tifton
✓Hanna, Wayne William	"	"
Monson, Warren G.	"	"
✓Reed, J. Fielding	"	Atlanta
✓Sell, Otto Ediwin	"	Experiment
Sell, W. H.	"	Athens
✓Smith, Albert E.	"	Griffin
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✓Studemann, John A.	"	Watkinsville
✓Usherwood, Noble R.	"	Atlanta
Utiley, Philip R.	"	Tifton
Wells, Homer D.	"	"
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